THE

170

EXECUTIVE DOCUMENTS

OF THE

SENATE OF THE UNITED STATES

FOR THE

FIRST SESSION OF THE FORTY-EIGHTH CONGRESS,

1883-'84.

VOLUME 3—No. 29.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1884.

48TH CONGRESS, 1st Session. | SENATE. | Ex. Doc. No. 29.

REPORT OF THE SUPERINTENDENT

OF THE

U. S. COAST AND GEODETIC SURVEY

SHOWING

THE PROGRESS OF THE WORK

DURING THE

FISCAL YEAR ENDING WITH

JUNE, 1883.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING,

In compliance with section 4690, Revised Statutes of the United States, the report of the Superintendent of the United States Coast and Geodetic Survey, showing the progress made during the fiscal year ending June 30, 1883.

DECEMBER 19, 1883.—Ordered to lie on the table and be printed.

TREASURY DEPARTMENT,
December 18, 1883.

SIR: In compliance with section 4690, Revised Statutes of the United States, I have the honor to transmit herewith, for the information of the Senate, a report addressed to this Department by J. E. Hilgard, Superintendent United States Coast and Geodetic Survey, showing the progress made in that work during the fiscal year ending June 30, 1883, and accompanied with a map illustrating the general advance in the operations of the Survey.

Very respectfully,

H. F. FRENCH,
Acting Secretary.

Hon. GEORGE F. EDMUNDS,
President of the Senate.

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REPORT.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, December 17, 1883.

SIR: In conformity with law and with the regulations of the Treasury Department, I have the honor to present herewith my report of the progress made in the work of the Coast and Geodetic Survey during the fiscal year ending with June, 1883.

The three parts into which this report is divided are arranged thus:

Part I is mainly occupied with a general statement of progress under the several heads of Field-work, Office-work, Discoveries and Developments, and Special Scientific work; with the estimates in detail for the next fiscal year, and with an explanation of those estimates.

Part II is devoted to detailed recitals of field-work begun, continued, or completed during the fiscal year, concluding with a reference to the office-work.

In Part III are comprised the several appendices relating to work in the field and office which appear annually, and other papers deemed worthy of publication as presenting discussions of the methods and results of the Survey.

PART I.

An examination of Appendix No. 1, which exhibits the distribution of the surveying parties, will show that there has been steady progress in the Survey in all of its branches, and it is believed that by a close and rigid scrutiny of expenditure the utmost results have been secured that the limited appropriations would admit of.

Among the more important operations during the past fiscal year may be enumerated the connection of the triangulation of the Atlantic coast with that of the Great Lakes; the resurvey of Long Island Sound, upon which, as demanded by the extensive commercial interests involved, a large force was concentrated; the approach to completion of the resurvey of Delaware Bay and River; the continuation of the explorations of the North Atlantic Basin by lines of deep-sea sounding and observations of surface, serial, and bottom temperatures; the extension of the line of transcontinental leveling of precision to Saint Louis, Mo.; the progress made in the geodetic surveys of the interior States and in the primary triangulation near the thirty-ninth parallel, intended to unite the triangulations of the Atlantic, Gulf, and Pacific coasts in one geodetic system; the verification for the Interior Department of the survey of the northern boundary of Wyoming Territory; the observations of the Transit of Venus of December, 1882, at stations in the United States, and at a station of the Transit of Venus Commission in New Zealand; the observation of the Total Eclipse of the Sun of May, 1883, at a station in the South Pacific, and the determinations of the force of gravity by means of pendulum observations at stations on the Atlantic and Pacific coasts, at stations of the Transit of Venus Commission in South America and New Zealand, and at other stations in the East Indies, Japan, and the Sandwich Islands.

GENERAL STATEMENT OF PROGRESS.

I.—FIELD-WORK.

ATLANTIC COAST.—During the year ending June 30, 1883, the work of the Survey has included the following operations upon the coasts and within the borders of the New England States: Triangulation and topography of Machias Bay and River, Me.; topography of islands in Moosa-bec Reach and shore-line of Chandler's Bay, Me.; topography of the shores of Pleasant River, Me.; hydrographic surveys in Narraguagus and Pigeon Hill Bays; soundings off Gouldsborough Bay and in Dyer's Bay and Rockland Harbor, Me.; series of tidal observations with self-registering tide-gauge continued, and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay; primary triangulation for the connection of the station upon Mount Washington, N. H., with the triangulation of Maine and of the Hudson River and Lake Champlain; occupation of stations for determining points in the triangulation of New Hampshire; stations occupied in continuation of the triangulation of the State of Vermont; line of deep-sea soundings run from off Nantucket across the Gulf Stream; observations continued at Providence, R. I., with a self-registering tide-gauge loaned to the city engineer; hydrography of the eastern entrance to Long Island Sound; self-registering tide-gauge established on the breakwater, Block Island; re-establishment of points of the old triangulation and determination of new points from Watch Hill westward for the resurvey of Long Island Sound; hydrographic resurvey of Fisher's Island Sound and New London and Stonington Harbors; topographic resurvey of the north shore of Long Island Sound to the eastward of Thames River; topographic resurvey of New London and vicinity; self-registering tide-gauge established at Fort Trumbull, New London, Conn.; determination of the geographical position of the new observatory of Yale College, and determination of points for the resurvey of the north shore of Long Island from the vicinity of Bridgeport, Conn., westward.

Work upon the coasts and within the limits of the States of New York, New Jersey, Pennsylvania, and Delaware has included a line of deep-sea soundings from the vicinity of Montauk Point, L. I., to the Bermuda Islands, and lines of soundings normal to the coast off the south shore of Long Island; a topographical survey of Fisher's Island, Long Island Sound; re-establishment of points of former triangulation and determination of new points on the south shores of Long Island Sound, in the vicinity of Montauk Point and Gardiner's Bay; topographic and hydrographic resurvey of the eastern part of the south shores of Long Island Sound; hydrographic resurvey of Gardiner's Bay and approaches; recovery and marking of triangulation points on the north shore of Long Island, between Hempstead Harbor and Horton's Point, N. Y.; topographic and hydrographic resurvey of the western part of Long Island Sound, in the vicinity of Throg's Neck; hydrographic resurvey of the approaches to New York Harbor; series of tidal observations continued with self-registering tide-gauge at Sandy Hook, N. J.; determinations of the force of gravity at Hoboken, N. J., and at Albany, N. Y.; lines of deep-sea soundings in the vicinity of New York Bay entrance; leveling operations for connecting the Coast and Geodetic Survey reference-mark at Albany, N. Y., with the primary triangulation station on Mount Mansfield, Vt.; primary triangulation across the State of New York for connecting the triangulation of Hudson River and Lake Champlain with that of the survey of the Great Lakes; continuation of the triangulation of the northern part of the State of New Jersey; additions of topographical details to original sheets of survey of the New Jersey coast between the highlands of Navesink and Tom's River; verification of hydrography in Delaware and Chesapeake Bays for the Atlantic Coast Pilot; triangulation, topography, and hydrography for the resurvey of Delaware River and Bay; resurvey of topography in the vicinity of Cape Henlopen, Del.; reconnaissance and extension westward of the triangulation of the State of Pennsylvania, and determination of the boundary line between Pennsylvania and West Virginia.

Within the District of Columbia and the State of West Virginia, and upon the coasts and within the boundaries of the States of Maryland, Virginia, and North and South Carolina, the operations of the Survey have included determinations of gravity by pendulum experiments at Baltimore and Washington; observations of the Transit of Venus at Washington, D. C.; con-

tinuation of the detailed topographical survey of the District of Columbia; examination of the monuments of the Arlington kilometer base, Va.; special survey for the Fish Commission near the Great Falls of the Potomac; continuation of topographic survey of the south shore of Hampton Roads, between Craney Island and Nansemond River; current observations at stations near the entrance of Chesapeake Bay, and thence southward; determination of the longitude of the University of Virginia, Charlottesville, and of the latitude also, and connection of the astronomical station with the primary triangulation; reconnaissance, triangulation, and hypsometric observations in the region about Washington, D. C., for the construction of a general map; reconnaissance for the extension of the primary triangulation near the thirty-ninth parallel westward in West Virginia and Ohio; lines of deep-sea soundings and temperatures off the coast of North Carolina; hydrographic surveys of Cape Fear River entrance and in Croatan and Pamplico Sounds, and a hydrographic survey in the vicinity of Cape Romain, S. C.

Upon the coast of Georgia, the east and west coasts of Florida; in the approaches to this coast; and upon the coasts and within the limits of the Gulf States, the following operations were in progress: occupation of the station at Savannah, Ga., for the determination of the longitude of the Transit of Venus station at Saint Augustine, Fla., by exchange of telegraphic signals; hydrographic resurvey of Saint John's River and Bar; reconnaissance of Saint John's River from Lake Monroe to Lake Washington; survey of the shores and lagoons of East Florida from Indian River Inlet southward, and from Key Biscayne northward; hydrographic survey between Jupiter Inlet and Key Biscayne; observations of currents at stations off Jupiter Inlet; deep-sea soundings, with serial temperatures, between the Bahamas and the Bermudas; topographic and hydrographic survey of the west coast of Florida between Charlotte Harbor and Tampa Bay; hydrography off the west coast of Florida to the northward and southward of Tampa Bay; reconnaissance for the connection of the Gulf coast triangulation in Mobile Bay, Ala., and vicinity, with the primary triangulation at or near Atlanta, Ga.; continuation of the survey of the coast of Louisiana west of the Mississippi River; survey of the coast of Louisiana from Sabine Pass eastward; hydrography of the coast of Texas from Galveston entrance eastward; topography of the shores of Nueces Bay, and triangulation in the vicinity of Matagorda Bay, Tex.; measurement of a base of verification and observations for azimuth.

Pacific Coast.—Upon the coasts and within the boundaries of the States of California and Oregon, of Washington Territory, and of Alaska, field-work has included the establishment of a magnetic self-registering record station at Los Angeles, Cal.; continuation of the primary triangulation northward from Point Concepcion; hydrographic survey from Monterey southward; observations at San Francisco, Cal., for the determination of the longitude of the Transit of Venus station near Fort Selden, N. Mex.; completion of the supplementary survey of the San Francisco Peninsula; determinations of the force of gravity at San Francisco, in connection with similar determinations at the Transit of Venus station in New Zealand, and at stations in New South Wales, the East Indies, Japan, and the Sandwich Islands; determinations of relative magnetic intensity and of the force of gravity at San Francisco, in connection with similar observations to be made at Point Barrow, Alaska; tidal observations with self-registering tide-gauge continued at Sancelito, Bay of San Francisco; occupation of stations of the primary triangulation north of San Francisco Bay; continuation of hydrographic survey in the vicinity of Point Arena, Cal.; hydrographic survey in the vicinity of Mendocino City, Cal.; continuation of the primary triangulation of the north coast of California; survey of the Umpquah River, Oreg.; continuation of the survey of Columbia River and tributaries; hydrographic surveys of Gray's Harbor and in the Straits of Fuca and Admiralty Inlet, W. T.; triangulation of Hood's Canal, W. T.; continuation of the hydrographic reconnaissance of the shore-line and harbors of Southeastern Alaska, and tidal observations continued with self-registering tide-gauge at Saint Paul, Kadiak Island, Alaska.

Interior States.—Work in localities between the Atlantic and Pacific coasts has included the occupation of the longitude station at Louisville, Ky., for the determination of the longitudes of additional stations in Kentucky by exchanges of telegraphic signals; observations for the latitudes of these stations; reconnaissance for the extension of the triangulation of the State of Kentucky; occupation of stations in continuation of the triangulation of the State of Tennessee; recon-

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naissance for the primary triangulation near the thirty-ninth parallel extended from West Virginia into Ohio and Kentucky; occupation of stations in continuation of the triangulation of the State of Ohio; reconnaissance for the extension of the triangulation of the State of Indiana; determinations of the latitude and longitude of stations in Indiana; transcontinental line of geodesic leveling extended from Mitchell, Ind., to Saint Louis, and thence to Kansas City, Mo.; continuation to the eastward of the primary triangulation in Illinois near the thirty-ninth parallel; occupation of stations in continuation of the triangulation of the State of Wisconsin; determinations of the longitudes of points in Arkansas, Missouri, Illinois, and Nebraska by exchange of telegraphic signals with Saint Louis, Mo.; continuation to the westward of the primary triangulation in Missouri near the thirty-ninth parallel; primary triangulation near this parallel in Nevada extended eastward, and a reconnaissance made for the extension eastward of the primary triangulation near the same parallel in Colorado; observation of the Transit of Venus of December, 1882, at Cerro Roblero, near Fort Selden, N. Mex., and completion of the work of verification of the northern boundary of Wyoming Territory.

The observations of the Transit of Venus at Auckland, New Zealand, were in charge of an Assistant in the Survey, under the direction of the Transit of Venus Commission. Advantage was taken of the opportunity to obtain determinations of the force of gravity at this distant station, and at other stations in the eastern hemisphere, for comparison with similar determinations at San Francisco and at Washington.

A special appropriation having been made by Congress for the observation of the Total Eclipse of the Sun at an island in the South Pacific, one of the younger officers of the Survey was ordered to join the expedition and to make at the eclipse station selected (Caroline Island) a series of pendulum experiments for the determination of gravity. Returning, he was instructed to obtain comparative determinations at stations in the Sandwich Islands and at San Francisco, Cal.

II.—OFFICE-WORK.

The records of field-work of the fiscal year ending June 30, 1883, received at the office have been duly distributed to the several divisions for examination and deduction of results, to be used in the production of the charts and other publications of the Survey.

In accordance with the office organization, the records which pertain to astronomical, geodetic, and magnetic observations are referred to the Computing Division; those relating to tidal observations, to topographic and hydrographic surveys, are referred to the Tidal, the Drawing, and the Hydrographic Divisions, respectively. The office labor proper consists in the verification of field records and computations; in the drawings and reductions for the preparation of the charts; in the engraving, electrotyping, printing, and issuing of the charts; in the computations for the prediction of tides, and the publication of Tide Tables; in the labor of the preparation and publication of the Coast Pilot; in the care of the records of the work, and in the making and maintenance of the geodetic instruments used on the survey.

Tide Tables of the principal ports of the United States for the year 1884, based on the reductions and discussions of the observations already made, have been published.

The drawings of forty-two charts have been in progress, and of this number twenty-eight have been finished, including fourteen for publication by photolithography.

Drawings have been made of five instruments of precision to accompany the annual reports, together with eighteen miscellaneous sketches and diagrams for the illustration of scientific papers.

Fifteen copper-plate engravings of charts and thirty-four of sketches and illustrations have been begun; four hundred and thirty-seven plates of charts and sketches have received corrections; the engraving of nineteen plates of charts has been continued; the plates of twenty-seven charts and eight sketches and illustrations have been completed. Forty-eight thousand three hundred and twenty prints were made from copper plates; of this number, fourteen thousand one hundred and sixty-five were charts and views illustrating the Atlantic Coast Pilot, and one hundred and eighty-two were transfer proofs, to be printed from stone. Eighteen alto and twenty-two basso electrotype plates were made for the office during the year, and twelve alto and fourteen basso plates for other Departments of Government.

III.—DISCOVERIES AND DEVELOPMENTS.

All obstructions or dangers to navigation discovered in the progress of the work are promptly reported to the Superintendent, and Notices to Mariners are issued for wide and free distribution, in which are stated the locality of the danger and the best way of avoiding it. Reference is made also to the charts of the Survey affected by the notice.

Six such notices were issued during the past fiscal year, numbered from 34 to 39, inclusive, in the regular series.

No. 34, dated August 24, 1882, gave the location and description of a dangerous rock in the eastern entrance to Fisher's Island Sound, as furnished by Lieut. Richardson Clover, U. S. N., Assistant, Coast Survey.

No. 35, bearing date of January 4, 1883, described dangerous rocks, reported by the same officer, in the western part of Fisher's Island Sound, and in the approaches to New London and Mystic Harbors.

No. 36, May 14, 1883, gives notice of a sunken wreck in the track of vessels along the New Jersey coast, reported and determined in position by Lieut. Commander W. H. Brownson, U. S. N., Assistant, Coast Survey.

In No. 37, June 8, notice was given of a wreck partly out of water in the track of vessels along the east coast of Florida, reported by Capt. F. Read, commanding the steamship Chalmette.

No. 38, June 19, gave an account of a dangerous rock, hitherto unknown, in Surge Narrows, Peril Strait. Southeastern Alaska, described in a communication received from Lieut. G. C. Hanus, U. S N., Assistant, Coast Survey.

No. 39, June 22, 1883, cautioned coasting vessels standing inside of the Five-Fathom Bank against a sunken vessel in their track off Townsend Inlet, N. J.

IV.—SPECIAL SCIENTIFIC WORK.

THE TRANSIT OF VENUS.

The results for the solar parallax, deduced from observations of the Transit of Venus of 1874, and considerations thence derived in regard to the best methods of observing the Transit of 1882, induced the Commission authorized by Congress to take early action in the organization of parties, and in the publication of detailed instructions for the observation of this event, so important both to astronomy and geodesy.

Observations of the Transit were made by officers of the Coast Survey at a number of stations, some of which were specially designated by the Transit of Venus Commission.

At Washington, D. C., a station was occupied at Fauth's Observatory, nearly opposite the southwest corner of the lower Capitol Park. The weather on the day of the Transit (December 6) being generally favorable, all four contacts were observed.

A station in New Mexico having been decided upon by the Commission, one was selected at Cerro Roblero, an isolated mountain mass rising abruptly to a height of nearly 1,700 feet from the right bank of the Rio del Norte, and about four miles from the military post at Fort Selden. Satisfactory observations were obtained of all four contacts at Cerro Roblero, under very favorable atmospheric conditions.

The transit was observed at the Davidson Observatory, in San Francisco, Cal.; at the Coast and Geodetic Survey station, Tepusquete, Cal., and at Lehman Ranch, Nev.

Observations of the Transit were made at Auckland, New Zealand, one of the stations of the Commission. But partial success attended the observations made at this station, the sun being at no time during the Transit entirely free from clouds.

Reports of the observations of the Transit made at the stations of the Transit of Venus Commission have been transmitted to the president of the Commission; duplicates of these reports will be preserved in the archives of the Survey.

Reports of observations made by officers of the Survey at other stations will appear as Appendix No. 16 to this report.

THE TOTAL SOLAR ECLIPSE OF MAY 6, 1883.

Under the provisions of a clause in the act of March 3, 1883, making an appropriation for the observation of the Total Eclipse of the Sun of May 6, at a station in the South Pacific Ocean, by an expedition to be organized for that purpose under the auspices of the National Academy of Sciences, with the co-operation of the Coast and Geodetic Survey, an officer of the Survey was ordered to report for duty on this expedition.

The observation of this eclipse was regarded with special interest, because of its having the longest totality of any that had ever been observed, nearly five and a half minutes. The opportunity for studying the physical phenomena of the eclipse would therefore be an exceptional one.

Caroline Island, a chain of small islands of coral formation in the South Pacific, was selected as the point of observation. The weather was clear during the totality, except a slight haze for a minute or two at beginning, and all four contacts were successfully observed.

Details are given in an abstract of the observer's report, which appears as Appendix No. 17.

FIELD CATALOGUE OF 1,278 TIME AND CIRCUMPOLAR STARS.

The first edition of a Field Catalogue of Time and Circumpolar Stars, prepared for the use of observers with portable instruments in the temporary observatories of the Survey, was published in 1874. It contained 983 stars. A new edition has been compiled, and is now ready for publication, which contains 1,278 stars, their mean places being given for the epoch 1885.0—the right ascensions to the nearest tenth of a second of time, and the declinations to the nearest second of arc. It includes the standard stars of the American Ephemeris and Nautical Almanac, of the English Nautical Almanac, of the Connaissance des Temps, and of the Berliner Astronomische Jahrbuch, together with stars selected from the standard catalogues, giving the preference to those of the Naval Observatory, Harvard College Observatory, and the Observatory of Greenwich.

Of the 1,278 stars in this catalogue, the apparent places of 752 are given in the ephemerides.

For the convenience of observers the catalogue is to be published separately in octavo form, and will also appear as Appendix No. 18 to this report.

DETERMINATIONS OF GRAVITY.

Determinations of the force of gravity, both absolute and relative, by means of pendulum experiments and observations, have been continued during the year. As an important factor in the investigation of the figure of the earth, such determinations have always formed an essential part of a geodetic survey.

In the United States the principal stations at which pendulums were oscillated were Albany, Hoboken, Baltimore, Washington, Saint Augustine, and San Francisco. A station was also occupied in Montreal, Canada.

Advantage was taken of the presence of observers experienced in pendulum work with the national expeditions for the observation of the Transit of Venus and the Total Solar Eclipse to obtain results for gravity at stations widely distributed over the earth's surface, thus adding valuable data for the determination of the compression of the earth at comparatively small cost.

At the Transit of Venus station in Auckland, New Zealand, were swung the three Kater invariable pendulums. These pendulums, of historic importance, which had been oscillated at Greenwich, Kew, and London, and subsequently at the Coast and Geodetic Survey stations in Hoboken and Washington, having been left in the custody of the Survey, the opportunity of obtaining by means of them observations strictly comparable, at stations geographically far apart, was a most valuable one. In accordance with instructions, the party of observation, on their return trip, swung the Kater pendulums at Sydney, New South Wales, at Singapore, Straits Settlements, British India, at Tokio, Japan, and at San Francisco.

The officer of the Survey who accompanied the Total Solar Eclipse expedition to Caroline Island, in the South Pacific, had in his charge pendulum No. 3, with instructions to oscillate it at the eclipse station, and also, upon his homeward voyage, at a station occupied upon the island of Maui by De Freycinet in 1819, and at a station in Honolulu, Sandwich Islands.

In order to obtain certain necessary observations supplementary to and completing the opera-

tions formerly executed for the purpose of connecting the American and English initial gravity stations, a Coast and Geodetic Survey officer was sent to Europe in May, 1883.

In the spring of 1883 instructions were issued for obtaining at San Francisco a series of gravity determinations to be made at Point Barrow, Alaska, by an observer of the Coast Survey attached to the Signal Service relief expedition which sailed from San Francisco about the middle of June.

RESULTS FOR THE LENGTH OF THE YOLO BASE.

A full account of the measurement of the primary base-line in Yolo County, Cal., with the new compensation base apparatus, was given in my last annual report. The results for length of the base as deduced from the measurements and comparisons are discussed in a paper which is published as Appendix No. 11 to this report.

The accuracy of the final result appears greater than that of any obtained for any other base-line on the survey. This is attributed mainly to the very careful handling of the apparatus during the measurement, and also to the precautions taken to secure daily comparisons with the standard.

The author of the paper expresses his belief that the question whether a base apparatus compensated for changes of temperature or one uncompensated would prove to be the most desirable is still unsolved. This is in consequence of the irregular contraction of the zinc bars as experienced in the present apparatus, the effects of which were only overcome by extra labor of comparison with the standard. The fact that the degree of accuracy actually reached is far greater than can be preserved, even in the very perfect measures of the angles of the first quadrilateral, does not set at rest the question of the most effective base apparatus, since besides accuracy, rapidity, and ease of handling, in a word, economy in measurement is also a very important factor.

VERIFICATION OF THE NORTHERN BOUNDARY OF WYOMING TERRITORY.

The occasion of the detail of an officer of the Coast and Geodetic Survey, at the request of the Interior Department, to make an examination upon the ground of the survey of the northern boundary of Wyoming Territory, made for that Department under contract, was fully stated in my last annual report.

At the beginning of the fiscal year 1882–'83 the work of verification was in full progress. By the close of August the field examination was finished. It was conducted under special instructions drawn up in accordance with the conclusions arrived at by the Commission appointed during the previous winter, and the work was executed in a manner entirely to the satisfaction of myself and the Secretary of the Interior.

PHYSICAL HYDROGRAPHY.

Much attention has been given during the past year to the study of questions in physical hydrography, the solution of which promises practical usefulness in connection with navigation and proposed public works.

A special investigation has been called for in the progress of the physical survey of Delaware Bay and River. This survey has now so nearly advanced to completion that a classification of its results has become possible with reference to the determinations of mean depth, areas of cross-section, and the laws which govern the changes in channel-ways and the movement of the tides.

In a report which was printed as Appendix No. 13 to the report for 1879, three rules were pointed out which simplified the conception of the physical scheme of Delaware Bay. They were deduced from a study of the printed charts, based upon the surveys of nearly forty years ago, but the new surveys, made with all modern refinements, confirm these rules in the most satisfactory manner. The author now furnishes the following statement, worked out from large collections of new data, which cannot fail to be valuable in considering plans for improvement to navigation or for the reclamation of tide-lands:

"*In the estuary of the Delaware, from League Island to the submerged delta, fifty miles below, the mean depth is constant; the widths and sections vary with the square of the distance, and the retard of the tide can be exactly stated in terms of the mean depth and width.*"

It is the first instance, perhaps, in which, with a constancy of mean depth, the effect of width upon the rate of tidal propagation could be accurately determined. In Appendix No. 9 to the report for 1878 the details of this investigation were given, and in Appendix No. 8 to my report for the present year are stated the conclusions derived from a careful study of the recent surveys.

MAXIMA AND MINIMA TIDE-PREDICTING MACHINE.

A description, with drawings, of a machine for computing tides, devised and constructed for the use of the Coast and Geodetic Survey, will be given in Appendix No. 10 to this report. With it can be determined mechanically the times and heights of high and low water at the numerous ports upon our coast for which Tide Tables are published a year in advance. These times and heights are given directly in figures upon a dial and scale, to be tabulated by the operator. The working capacity of the machine is estimated to be at least that of twenty computers. Results obtained by means of it for the Boston tides of 1884, and compared with results from computation, presented a satisfactory agreement.

HARMONIC ANALYSIS OF THE TIDES OF SANDY HOOK.

At Sandy Hook, N. J., which is a port of reference for the tides on the south coast of Long Island, for those on the New Jersey coast between Keyport and Cape May, and for the tides at Cape Henlopen and the Delaware Breakwater, a self-registering tide-gauge has been maintained for several years. In order to deduce a series of tidal constants which will serve in future for the close prediction of tides at this important station, the hourly co ordinates of the heights of the tide as measured from the curves recorded for six years (1875 to 1881, inclusive) have been treated by the method of harmonic analysis. This paper appears as Appendix No. 9 to this report.

In a report on a discussion of the tides of Penobscot Bay (Appendix No. 11 for 1878) a full account was given of the method of applying the harmonic analysis to the investigation of the laws of tidal action.

DEEP-SEA EXPLORATIONS IN THE WESTERN PART OF THE NORTH ATLANTIC OCEAN.

The deep-sea explorations which have been prosecuted for several years past in the western part of the North Atlantic Ocean have been continued. For the special purpose of developing the limits and general character of that part of the Atlantic Basin between Bermuda and the Bahamas, and to the eastward as far as St. Thomas, a systematic investigation of the configuration of the ocean bed in those localities was made during the past winter by deep-sea sounding and dredging, with observations of surface, serial, and bottom temperatures.

Many interesting results were obtained during this cruise, one of the most noteworthy of which was the successful sounding taken at the great depth of four thousand five hundred and sixty-one fathoms about seventy-five miles to the northward of Porto Rico. The temperature at this depth was found to be 36¼° Fahr., and the specimen-cup brought up brown ooze. No record is known of any sounding from which bottom specimen and temperature have been obtained at a depth equaling this.

A model of the bottom of our Atlantic coast and the Gulf of Mexico, based upon the Coast Survey soundings, was constructed at this office, and being exhibited at the recent International Fisheries Exposition in London attracted much notice and received great commendation.

EXPLANATION OF ESTIMATES.

With the detailed estimates for the fiscal year ending June 30, 1885, which were transmitted to the Treasury Department in November last, was submitted the following statement:

In submitting the estimates for the Coast and Geodetic Survey for the fiscal year 1884–'85, I beg leave to bring to your attention the points in which they differ from the appropriations for the current fiscal year, and to ask your approval of the same.

The aggregate amount asked is $670,500, while the aggregate appropriation for the current year is $655,290. There is no great disparity in these amounts, but it must be noted that this year's appropriation contains an amount of $100,000 for the building of a new steamship for the coast of Alaska.

The chief increase in the estimates is for the item of "party expenses," which comprise the pay of those temporarily employed as recorders, signal-men, hands, cooks, drivers or boatmen, as the case may be, the subsistence and transportation of the parties, and all requisite materials, tents, boats, and all other necessary expenses incident to the work.

The object of proposing this increase is to obtain a proper economic proportion between the expense of putting the surveying parties in the field and the length of time that they can be kept at work. This should be as long as permitted by the season favorable for field-work in the several localities. In order to meet this condition it is necessary that the amount available for "party expenses" should be at least half as large again as it has been of late years, and I am constrained by a consideration of reasonable economy to submit estimates for an increased amount.

As compared with the vast extent of our coast, the localities at which the work is going on are few and far between, and the only other mode of doing the work with due economy, with the present means, would be to discontinue the survey for the present at many points where it is now in progress.

The next item in the appropriation, that for "transcontinental geodetic work," is slightly increased for the same considerations.

The item for "aid to State surveys" is increased by $4,000, owing to the growing demand for this means of verifying the surveys of the different States.

In the item of "pay in field" the small increase in the estimate is rendered necessary by the reasonable expectation of advancement in the lower grades. The probable diminution of expenditure from natural causes in the higher grades may make the additional expenditure unnecessary.

The aggregate of the "pay in office" remains unchanged, although variations may occur in details.

The "rent" charges equally remain unchanged.

The amount for "office expenses" is increased by about $6,400, owing to the constantly growing demand for the results of the work.

The item for "repairs of vessels" is increased by $3,000, to bring it up to the ordinary amount (reduced 10 per cent. last year), and by $12,000 for putting new boilers in the steamer Hassler, which has now been in service twelve years.

I trust that the foregoing explanations will warrant your approval of the estimates submitted.

ESTIMATES.

For every expenditure requisite for and incident to the survey of the Atlantic, Gulf, and Pacific coasts of the United States, including the survey of rivers to the head of tide-water or ship navigation; deep-sea soundings, temperature, and current observations along the coasts and throughout the Gulf Stream and Japan Stream flowing off the said coasts; tidal observations; the necessary resurveys; the preparation of the Coast Pilot; a magnetic map of North America, and the compilation of data or a general map of the United States; and including compensation, not otherwise appropriated for, of persons employed on the field-work, in conformity with the regulations for the government of the Coast and Geodetic Survey adopted by the Secretary of the Treasury, and including allowance for subsistence to officers of the Navy attached to the Survey, not exceeding one dollar per day, as allowed by act of Congress approved June 12, 1858; and also including the repairs, outfit, and equipment of vessels used in the Survey, to be expended under the following heads:

For Party Expenses.—For continuing the survey of the unsurveyed portions of the coast of Maine eastward from Chandler's River towards Quoddy Head; for examination of reported dangers and changes on the eastern coast and Vineyard Sound; for continuing resurvey of Long Island Sound; for completing resurvey of Delaware Bay, including current observations; for continuing examination of changes and resurveys on the sea-coast of New Jersey; for surveys of estuaries of Chesa-

FOR PARTY EXPENSES—Continued.

peake Bay, including Chincoteague Bay, Md., and of sounds and tide-water passages in North and South Carolina not heretofore surveyed; for continuing the survey of the sounds on the eastern coast of Florida, including the Saint John's River; for continuing the survey of the western coast of Florida from San Carlos entrance southward, and from Bayport southward, and hydrography of same; for examining the changes in Mobile Bay, and surveying around the Chandeleur Islands and the waters on the east coast of Louisiana; for continuing the survey of the coast of Louisiana from Bayou La Fourche westward, and between Vermilion Bay and Mermenteau Pass, including hydrography on the coasts of Texas and Louisiana west of the Mississippi River; for making the requisite verification of the work and for re-examinations of entrances on the coast of Texas; to make off-shore soundings along the Atlantic coast, and current and temperature observations in the Gulf Stream; for continuing the researches in physical hydrography relating to harbors and bars; for determinations of geographical positions (longitude party); to continue the primary triangulation from Atlanta towards Mobile; for continuing an exact line of levels from the Gulf to the transcontinental line of levels between the Atlantic and Pacific Oceans; to continue tide observations on the Atlantic and Gulf coasts, and researches relating thereto; to continue magnetic observations on the Atlantic and Gulf coasts; to continue gravity experiments; to continue the compilation of the Coast Pilot and to make special hydrographic examinations for the same; for compilation of data for a general map of the United States; for continuing the survey of the coast of California, namely, for topography from San Luis Capistrano towards San Diego, from Point Piedras Blancas to Cape San Martin, and supplementary surveys near San Francisco; for primary triangulation from San Luis Obispo northward, from Santa Clara southward, and from Trinidad northward, including a line of precise levels from Sancelito to the transcontinental line of levels; for hydrography off the same coast; for continuing the survey of the coast of Oregon, namely, survey from Umpquah River southward, and including such river mouths as may be specially called for, and off-shore hydrography, and the survey of Columbia River and Willamette River to the head of ship navigation; for continuing the survey of the coast of Washington Territory, namely, continuing the triangulation, topography, and hydrography of Fuca Strait, of the estuaries of Puget Sound, and of Possession Sound; for the transfer of the steamer Patterson to the waters of Alaska, the preparation for and making hydrographic surveys in the same; for miscellaneous work and contingencies of all kinds, including traveling expenses of officers and men of the Navy on duty not specified in the above, and for any special surveys that may be required by the Light-House Board or other proper authority; for continuing tide observations on the Pacific coast; for magnetic observations on the Pacific coast; for traveling expenses of the Superintendent and his party on duty of inspection, and for objects not hereinbefore named that may be deemed urgent; in all for party expenses $246,000

TRANSCONTINENTAL GEODETIC WORK.—For transcontinental geodetic work, including line of leveling between the Atlantic and Pacific Oceans 36,000

FURNISHING POINTS FOR STATE SURVEYS.—For furnishing points for State surveys. 20,000

PAY OF FIELD OFFICERS.—For pay of the Superintendent and forty-six Assistants, nine Subassistants, and twelve aids, constituting the normal force of the Survey, in conformity with Treasury Regulations of March 18, 1881 127,700

PAY OF OFFICE FORCE.—For pay of persons employed in the Office of the Coast and Geodetic Survey, under the regulations of the Secretary of the Treasury:

For pay of mathematicians and computers employed in the reduction and discussion of field-work; of draughtsmen; of engravers, copper-plate printers, and electrotypers; of computers for the discussion and prediction of tides; of persons employed in collecting, verifying, and arranging the data for the Coast Pilots; of the hydro-

PAY OF OFFICE FORCE—Continued. graphic draughtsmen in office of hydrographic inspector; of the disbursing agent and accountants; of the mechanicians in the instrument shop; for the reconstruction and repairs of instruments, including carpentry; and of persons employed in the official correspondence; writing and copying reports and records; preservation of the records of the Survey; distribution and sale of charts; the pay of watchmen, messengers, and packers	$128,500

GENERAL EXPENSES, COAST AND GEODETIC SURVEY.

RENT OF BUILDINGS:	
For rent of buildings for offices, work-rooms, and work-shops in Washington	10,500
For rent of fire-proof building No 205 New Jersey avenue, including rooms for standard weights and measures; for the safe-keeping and preservation of the original astronomical, magnetic, hydrographic, and other records; of the original topographical and hydrographic maps and charts; of instruments, engraved plates, and other valuable property of the Coast and Geodetic Survey	6,000
OFFICE EXPENSES.—For the purchase of new instruments; for materials and supplies required in the instrument shop for reconstruction and repairs, and for books, maps, and charts, including subscriptions; for materials for the Drawing Division and for chart-mounting, including drawing-paper; for copper plates; chart paper; printer's ink; copper, zinc, and other materials for electrotyping; engraver's and printer's supplies; materials for carpenter's shop; for extra engraving, including map of the United States, and the necessary copper plates therefor; and for photolithographing charts for immediate use; for stationery for the office and field parties; transportation of instruments, supplies, &c.; office wagon; fuel; gas; telegrams; ice; washing; extra labor; office furniture and repairs; and for allowances to the Assistants in charge of the office details, in accordance with the regulations of the Secretary of the Treasury; for miscellaneous expenses; contingencies of all kinds; and for traveling expenses of Assistants and others employed in the office sent on special duty in the service of the office	47,800
PUBLISHING OBSERVATIONS.—For continuing the publication of observations and their discussions made in the progress of the Coast and Geodetic Survey, including compensation of civilians engaged in the work, the publication to be made at the Government Printing Office	6,000
REPAIRS AND MAINTENANCE OF VESSELS.—For repairs and maintenance of vessels used in the Coast and Geodetic Survey, including new boilers for the steamer Hassler	42,000
Total amount estimated for Coast and Geodetic Survey for 1884–'85	670,500
Total amount appropriated for Coast and Geodetic Survey for 1883–'84	655,290

PART II.

In this part of the report are given condensed statements of the operations of the field parties of the Survey in the several localities upon the Atlantic and Pacific coasts and in the interior States. These statements are arranged in a geographical order, under the headings of the several sections. Upon the Atlantic coast they include localities between Machias Bay, Me., and Matagorda Bay Tex.; and upon the Pacific, portions of that coast between Los Angeles, Cal., and Point Barrow, Alaska.

In the interior States the geodetic surveys which are intended to complete the connection between the work on the eastern and western coasts, and those in progress for the purpose of furnishing points to State surveys, are referred to in sections, each of which comprises two or more States, beginning with those nearest the Atlantic coast.

Appendix No. 1 exhibits in tabular form the distribution of the surveying parties, the names of persons conducting field-work, and the nature of the work performed.

Assistant Richard D. Cutts, in charge of the Coast and Geodetic Survey Office, presents in Appendix No. 4 a comprehensive report of the operations of the office during the fiscal year, and accompanies it with the reports of the chiefs of the several office divisions. The close relation between efficient administration in the office and results commensurate with the means employed in the field has been fully recognized by Assistant Cutts, and my indebtedness to him for constant and cordial co operation is very great.

The report of Commander C. M. Chester, U. S. N., Hydrographic Inspector, appears in Appendix No. 5. I have committed to him all matters pertaining to the arrangement of hydrographic work, the assignment to duty of naval officers attached to the Survey, the care and disposition of vessels, and the direction of the labors of the hydrographic draughtsmen. His aid and counsel in this branch of the service I have found invaluable. With his report is given a list of the officers of the Navy on duty in the Survey during the fiscal year, a statement of the condition of the vessels engaged in the work, and a summary of the work accomplished by the hydrographic draughtsmen employed in the office.

Lieut. J. E. Pillsbury, U. S. N., was on duty during the year as assistant hydrographic inspector. By his systematic and earnest efforts the office was enabled to keep the charts of the Survey up to the latest dates in respect to changes made or contemplated in Aids to Navigation. In these efforts he had the hearty co-operation of the Light-House Board, through its secretaries. For early information in regard to such changes Commander Chester expresses his thanks to those officers.

Lieut. Richardson Clover, U. S. N., Assistant, Coast Survey, was on duty part of the year, and assisted in the preparation of the plans and specifications for the new steamer for the Pacific coast.

SECTION I.

MAINE, NEW HAMPSHIRE, VERMONT, MASSACHUSETTS, AND RHODE ISLAND, INCLUDING COAST AND SEA-PORTS, BAYS, AND RIVERS. (SKETCHES NOS. 1 AND 3.)

Triangulation and topography of Machias Bay and River, Me.—As soon after the beginning of the fiscal year as practicable, Assistant C. H. Boyd proceeded to Machias Port, Me., under instructions to take up the survey of Machias Bay and River. Mr. Boyd's first efforts upon his arrival,

early in August, 1882, were directed towards the recovery of stations of the triangulation begun in 1862 but interrupted at that time by the course of public events. Two of these stations, "Howard" and "Lowell," were identified, and with the base thus obtained all needed triangulation points were determined.

The shore-lines of the bay and rivers with the islands in the vicinity were delineated upon two topographic sheets, extending from Cross and Libby Islands, at Machias Bay entrance (and including Machias Port), to the bridges over the Machias and East Machias Rivers, some fifteen miles from the sea. Field-work was closed on the 10th of November. Mr. E. L. Taney, aid, served very acceptably in the party during the entire season; Mr. C. W. Lyman during part of the season. The statistics of the work are as follows:

Shore-line surveyed, miles	66
Roads, miles	5
Area of topography, square miles	3
Stations occupied in triangulation	9
Positions determined	24

Reference will be made to the work of Assistant Boyd during the winter season on the coast of Louisiana under the head of Section VIII.

Topography of islands in Moos-a-bec Reach, and shore-line of Chandler's Bay, Me.—It being desirable to fill certain gaps in the topographic survey of the islands near the eastern entrance to Moos-a-bec Reach, and of the northern shore of the reach in the vicinity of Jonesport, Assistant Eugene Ellicott was directed to take up this work, and arrived at Jonesport early in August. After completing the survey of the outer face of Head Harbor Island, Steele's Harbor Island, and Great Wass Island, Mr. Ellicott took up the unfinished topography of the northern shores of the reach, near Jonesport, and between West River and Carrying-Place Cove. Much cutting had to be done here, the country being densely wooded. This portion of the survey was finished towards the close of October, and work upon the Chandler's Bay sheet was in progress when Mr. Ellicott's services were required in another field of labor, and under instructions November 11, further operations were suspended. Following are the statistics of the survey:

Shore-line surveyed, miles	32
Area of topography, square miles	13

Work executed by Mr. Ellicott under subsequent assignments will be referred to under the heads of Sections III and VI.

Topography of the shores of Pleasant River, Me.—The completion of the topographical survey of the shores of Pleasant River, Me., to the head of tide-water, having been assigned to Assistant A. W. Longfellow, that officer took the field as soon as funds were available for the work, and, beginning about a mile below Addison's Point Village, extended the topography of the river-shores to a little above Columbia Falls Village, including the mill-pond there. Vertical angles for contour curves gave an elevation for this pond of 17.4 feet above high water.

Both Addison's Point and Columbia Falls have been ship-building localities. Vessels of one hundred and fifty tons can load at the Falls, and two were built there during the preceding season. The Pleasant River is a tidal stream up to the Falls, winding through salt marshes, which are generally diked, but subject to overflow at spring and storm tides to their limits at the upland. The survey was completed on the 24th of November. Statistics are as follows:

Shore-line surveyed, miles	33
Streams and brooks traced, miles	22
Roads, miles	37
Area of topography, square miles	14

Hydrographic surveys in Narraguagus and Pigeon Hill Bays; soundings off Gouldsborough Bay and in Dyer's Bay and Rockland Harbor, Me.—Under instructions directing a hydrographic survey of Pigeon Hill Bay and its eastern approaches, with other hydrographic work in the adjoining bays and in Rockland Harbor, Lieut. H. G. O. Colby, U. S. N., Assistant in the Coast and Geodetic Survey, arrived with his party in the schooner Eagre in Pigeon Hill Bay (sometimes called Boisbu-

bert Harbor) early in July, 1882. Having selected an anchorage about half a mile above Gull Rocks, and established a tide-gauge which was referred to a bench-mark upon Boisbubert Island, soundings were begun, and the work was prosecuted as rapidly as good results would allow. Great care was taken to find all hidden dangers; ledges and rocks were buoyed and developed separately; fishermen and local pilots were consulted as to names familiar by long usage in the locality.

Lieutenant Colby remarks in regard to Boisbubert Harbor that it is spoken of as a place much exposed in southerly gales, and that such is the impression formed at first sight, and in a measure true, the formation of the land giving little protection from the wind. But from the sea the protection is almost perfect, the rocks and ledges which make this harbor so difficult of access from the southward forming a breakwater, so that during the heavy winter gales nothing more than "a chop" is experienced.

The following extracts from Lieutenant Colby's report will be of interest:

"Petit Manan Bar, which extends from Petit Manan Point to the islands, is one continuous line of ledges and rocks; there are two channels over the bar, one close in to the point and the other about two-thirds of the distance to the islands. The former is crooked and narrow, with several detached rocks, not fit for strangers; the latter is buoyed and can be used by vessels of light draught after two hours' flood. * * * The tide runs nearly east and west across the bar. In anything more than ordinary weather there is one line of breakers the entire length of the bar, and it cannot be crossed with safety."

"The 'Whale' is a rock which lies about half a mile south of Egg Rock; it is one of the principal dangers of Pigeon Hill Bay, as at high water, with little or no swell, there is nothing to mark the locality of this rock. Between the Whale and Egg Rock no dangers were found, which leads to the belief that there is a good channel here by keeping clear of the rocky point making off to the southward of Egg Rock. This ledge was developed by placing two buoys on the two shoalest spots, and running lines across nearly at right angles, in order to show as nearly as possible the shape and formation, which at half-tide has, as the name implies, the appearance of a large whale.

"To the north of Egg Rock, between it and Little Bubert, the bottom is very irregular, composed of ledges and large bowlders, and is not a safe place for vessels of any size."

The hydrography of Pigeon Hill Bay was completed before the close of the season, with the exception of some soundings to the northeast of Pond Island and the ledge known as Jordan's Delight. During the summer an iron spindle was fixed by the Light-House Board upon the southern point of this ledge. The spindle was carefully established in position by the hydrographic party and used as a signal.

Additional work executed by Lieutenant Colby included soundings for a more complete development of the bottom off Gouldsborough Bay, examination of a doubtful spot in Dyer's Bay, and soundings needed to complete the survey of Rockland Harbor, Me.

During the season ending in November, 1882, the following-named officers were attached to the party: Ensigns David Daniels, O. G. Dodge, and A. Jeffries, U. S. N. Of the ability and readiness with which the duties assigned to these gentlemen were performed Lieutenant Colby expresses his appreciation in his report.

Statistics of the season's work are as follows:

Miles run in sounding	395
Angles measured	4,676
Number of soundings	24,055

Tidal observations.—As heretofore for several years past, the series of tidal and meteorological observations at Pulpit Cove, North Haven Island, Penobscot Bay, has been kept up by Mr. J. G. Spaulding. A continuation of this series for about six years longer will be desirable at this fundamental station, in order to obtain data which will fulfill the conditions required for investigating the laws of the tides on the Atlantic coast of the United States. But few interruptions of the record have occurred since its beginning in 1870, the self-registering tide-gauge being supplied with a hot-water apparatus, which has kept it in action in the coldest winter weather.

Primary triangulation for the connection of the station upon Mount Washington, N. H., with the triangulation of Maine and of the Hudson River and Lake Champlain.—The tower and tripod erected over the Coast and Geodetic Survey station on the summit of Mount Washington were used during the season of 1881 for the secondary triangulation of New Hampshire. There still remained, however, to be observed at that station the primary lines connecting the triangulation of Maine with the series covering the valleys of the Hudson River and Lake Champlain; and for the purpose of avoiding a not improbable risk of the overturning or tilting of the tower by the violent storms of winter, it was deemed advisable to have the remaining and actually necessary observations made there at as early a date as possible.

Accordingly, at the beginning of the fiscal year, Assistant Richard D. Cutts was instructed to organize a party to take charge of this special work, and to direct it in person in the field at such times and for such periods as his duties as Assistant in charge of the office would permit.

Mount Blue, in Maine, Mount Mansfield, in Vermont, and other stations to be selected in the northern part of New Hampshire and Maine and along the boundary line between the United States and Canada were to be included in the scheme of work, which, as thus laid out, involved an extensive reconnaissance. Under the direction of Assistant Cutts this reconnaissance was made by Mr. John A. McNicol during the month of July. Many points were examined and the positions of seven stations were approximately fixed, including Oxford Mount, in Canada, and Camel's Rump and Mount Azischohos, in Maine. At this last-named station a signal was erected and observed upon from Mount Washington. The summits of the other mountains were so densely wooded that it was not possible to open the different lines and to observe from Mount Washington during the same season.

Near the close of July the occupation of Mount Washington station began. Heliotropers had been posted on Mount Blue and Mount Pleasant, Me.; Gunstock, N. H.; Mounts Killington and Mansfield, Vt. Every favorable opportunity was taken to advance the work, and upon reaching the station, August 10, Assistant Cutts assumed personal charge of the party.

The directions of the five principal stations were each determined by thirty-five observations taken in seven positions of the instrument; vertical angles were also measured on the same summits, and a few on other summits, the total number of such measurements being one hundred and sixty-two.

Observations were completed September 13. The lengths of the lines observed from Mount Washington are as follows:

	Miles.
To Killington	88.5
To Mount Mansfield	77.0
To Mount Azischohos	46.0
To Mount Blue	57.0
To Mount Pleasant	29.5
To Gunstock Mountain	52.0

Occupation of stations for determining points in the triangulation of New Hampshire.—A reconnaissance of the eastern part of the State of New Hampshire for extending the triangulation of that State was begun by Prof. E. T. Quimby, Acting Assistant, in accordance with instructions issued at the beginning of the fiscal year. Catamount Mountain, in Pittsfield, Merrimac County, having been selected as the first station, was occupied between the middle of July and the close of August, and early in September Professor Quimby moved his party to station Blue Job, in Farmington, Stafford County, making in the intervals of occupation of these two stations a reconnaissance still further eastward.

Observations at Blue Job met with frequent interruptions from storms, severe gales of wind, and fog, but they were finally completed before the close of the season in October, and arrangements were then made for the occupation during the next season of Moose Mountain, in Brookfield, Carroll County. Statistics are:

Horizontal directions determined	200
Vertical angles measured	30

Stations occupied in continuation of the triangulation of the State of Vermont.—The duty of continuing the triangulation in the southern part of the State of Vermont having been assigned to Prof. V. G. Barbour, Acting Assistant, by instructions dated July 1, 1882, preparations were begun in the early part of the month for the occupation of Halifax station, in Windham County. The observations of horizontal and vertical angles required at this station were completed by the close of July, and a few days early in August were occupied in stationing heliotropers on Mounts Mansfield and Killington for the primary triangulation party on Mount Washington referred to under a previous heading in this section.

Preliminary arrangements were at the same time made for the occupation of Haystack Mountain, in the town of Wilmington. A temporary camp was established at the foot of the mountain until a road could be cut to a point half a mile distant from the summit. At this point, eight hundred feet below the summit, the camp of occupation was established. From the camp to the station, the ascent being too steep for horses or oxen to travel, the observing tent and instruments were carried by hand. Observations were begun August 18 and completed on the 30th, eight signals and the church spires of three villages having been observed.

Mount Anthony, in Bennington County, was the last station occupied, and on the 14th of September, field-work was closed. Statistics are:

Horizontal angles measured	816
Vertical angles measured	360

Line of deep-sea soundings from off Nantucket across the Gulf Stream.—In continuation of the investigations relating to the depth and temperature of the western part of the North Atlantic, Lieut.-Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, upon assuming charge of the hydrographic party on board the steamer Blake in August, 1882, was instructed to run a line of soundings, with serial temperatures, from the vicinity of Nantucket across the course of the Gulf Stream. The Blake had already been engaged in similar work under the direction of Commander J. R. Bartlett, U. S. N., Assistant Coast and Geodetic Survey. For reference to this see Sections II and VI. The vessel being fitted with all needful apparatus, the work assigned to Lieutenant-Commander Brownson occupied but a few days, and was completed August 24. His line of soundings began off Nantucket, in latitude 40° 52′, longitude 69° 49′ west of Greenwich, and ended in latitude 37° 19′, longitude 66° 35′ west of Greenwich. At this point a depth of two thousand seven hundred and fifty-six fathoms was sounded, the temperature at this depth being 36½° Fahr. Returning towards the coast, a shorter line of soundings was run, and the Blake then proceeded to Providence, R. I., where preparations were made for off-shore work south of Long Island.

The statistics presented by Lieutenant-Commander Brownson in his report are as follows:

Length of sounding lines, in miles	332
Number of soundings taken	40
Serial temperature stations, number of	27
Water temperatures observed, surface	44
Water temperatures observed, intermediate	173
Water temperatures observed, bottom	24
Specimens of bottom, number of	17

Tidal observations.—Records of tidal curves, from the self-registering tide-gauge loaned by the Coast Survey to the engineers of the city of Providence in 1872, are transmitted at intervals to this office. Results of value have already been obtained from a discussion of these observations, and it is hoped that nothing will occur to prevent the completion of the series.

SECTION II.

CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE, INCLUDING COAST, BAYS, AND RIVERS. (SKETCHES Nos. 1, 3, AND 4.)

Deep-sea soundings from the vicinity of Montauk Point to the Bermuda Islands and lines of soundings normal to the coast off the south shore of Long Island.—At the beginning of the fiscal year the steamer Blake had been thoroughly equipped for deep-sea explorations under the direction of Commander of J. R. Bartlett, U. S. N., Assistant Coast and Geodetic Survey. The interesting results obtained by that officer during the preceding season, in the course of his explorations of the Gulf Stream, were stated at length in my last annual report. In continuation of these investigations, under instructions dated in June, 1882, Commander Bartlett, with his party in the Blake, left New York July 15, and the next day began a line of soundings with surface, bottom, and serial temperatures from off Montauk Point towards the Bermudas.

Three additional lines were run before the return of the steamer to New York in August, one from the Bermudas to Cape Hatteras, one from Cape Henry to the outer limits of the Gulf Stream, and one from the last station reached on this line to New York, where the Blake arrived August 14.

The leading facts of the cruise are stated in the following extracts from Commander Bartlett's report:

"The first sounding taken on this line (from off Montauk Point to the Bermudas) was just beyond the one hundred-fathom curve in two hundred and sixty-six fathoms. Soundings were then taken every twenty miles until July 20; after this date we made only an occasional sounding. * * * We crossed the ordinary limit of the Gulf Stream in latitude 39° 15′ north, longitude 70° west. From our departure from Montauk light, I steered direct for the Bermudas, being a course SSE. (T. M.); this course I intended changing on entering the Stream to allow for the set of the current. I crossed the imaginary limit, and continued the same course of SSE. until reaching latitude 38° 45′ north, longitude 70° 13′ west. The temperature of the surface water just outside of the one hundred-fathom curve was 68°; it gradually rose to 70°, 72°, and 73°, and at last to 75°, when the course was changed to S. by W. (T. M.) to allow for a two-knot current and the time necessary to cross the Stream to its southern limit.

"No easterly current was detected on this new course until reaching the vicinity of latitude 37° 02′ north, longitude 70° 40′ west. During the time that we were in the current we had no observations of sufficient value to give its direction or force. The wind was fresh from the southwest and the current northeasterly at least three miles per hour. We lost the current again in about latitude 36° 35′ north, longitude 69° 25′ west. On the southern side of the Stream I observed immense quantities of the Gulf weed extending in long lines with the wind and sea. * * * The character of the bottom of the several soundings was a light gray ooze, as previously found by H. B. M. S. Challenger. * * * The temperature of the surface water was taken at every mile of distance run, by means of an ordinary thermometer, the water for that purpose being drawn over the stern, where it was stirred up by the propeller. The temperature of the suface was also taken forward at each sounding and serial station.

"The surface temperatures taken did not indicate any bifurcation of the Stream into warm and cold bands, as had been previously reported. The temperature of the surface increased gradually from 68° near the hundred-fathom line to 75°, and remained at 74° and 75° until we entered the Stream when it rose as high as 80° and 81°, and continued at nearly the same temperature all the way to the Bermudas. There was a slight rise and fall of the temperature of the surface water between day and night, and also a fall during heavy squalls of rain, but even when we found the fall of temperature at the surface, it was not indicated at five and ten fathoms.

"At every sounding the temperature at the bottom was obtained by a Miller-Casella thermometer attached to the stray line about ten feet above the sinker. The temperature of the bottom at the first sounding of two hundred and sixty-six fathoms was 40½°. I found as low a temperature as this close to the shore in twenty-four fathoms, but it increased two or three degrees as the water deepened towards the one hundred fathom line. At eleven hundred and seventy-four fathoms the

bottom temperature was 37½°; at fifteen hundred fathoms from 36° to 36½°; at greater depths it was 36° and 35½°, which was the lowest that we obtained.

"From the first sounding, a series of temperatures were taken every ten miles to a depth of twenty-five fathoms, temperatures being taken five, ten, fifteen, and twenty-five fathoms. * * * The temperatures below the surface on all lines were taken with the Miller-Casella thermometers The readings of these thermometers have not been corrected for any error owing to pressure, but those in use were compared each day with a standard, and any which did not record accurately, or in which the mercury was broken, were laid on one side.

"After steaming eighty miles, and just before reaching the supposed ordinary limit of the Stream, the serials to twenty-five fathoms were increased so as to be only five miles apart on the remainder of the line to the Bermudas. A serial was taken every ten miles to two hundred fathoms at the following depths: Fifty, seventy-five, one hundred, one hundred and fifty, and two hundred fathoms; a serial to eight hundred fathoms every twenty miles, at three hundred, four hundred, six hundred, and eight hundred fathoms, each serial being complete from the surface to the greatest depth. All of the temperatures below the surface were taken with the thermometer fastened to the steel sounding wire, a thirty-six pound lead being used as a sinker."

Commander Bartlett arrived at the Bermudas on the afternoon of July 25, and remained in port only long enough to swing the vessel so as to determine any change in the deviation of the compass since swinging at Niantic Bay, Long Island Sound, before starting on the cruise. He found a slight change in the deviation, which he attributed to the effect of the dynamo-machine connected with the electric light.

Leaving the Bermudas, a line for temperatures only was run to Cape Hatteras, temperatures of the surface being taken every mile; those to twenty-five fathoms every ten miles; those to four hundred fathoms every thirty miles, and to eight hundred fathoms every sixty miles. Upon entering the current of the Gulf Stream the deep serials were taken at half the above distances.

Bad weather was encountered upon nearing Hatteras, and the position of the last serial which could be obtained in the heavy sea having been established, the steamer put into Hampton Roads August 2. Here Lieutenant-Commander W. H. Brownson reported on board for duty in anticipation of taking command of the Blake, and on the 10th of August Commander Bartlett began a line of soundings due east from Cape Henry light. The soundings were taken every five miles to the one hundred fathom curve; at this point two and a half miles apart, and then five miles apart to the end of the line. The temperature of the surface was taken every mile; to twenty-five fathoms every five miles, and to four hundred fathoms every ten miles.

With reference to this line Commander Bartlett remarks that he did not find the warm water or the Gulf Stream current until he had nearly crossed the imaginary Stream as represented on the chart. On reaching the Stream he shaped a course for Navesink lights, taking soundings and serials as on the previous line.

Some additional extracts from Commander Bartlett's report are here given, as presenting his views, derived from facts observed during the cruise. He says very justly, however, after stating that he has endeavored to draw attention to the most important facts, that no definite conclusion can be drawn from data obtained on only two lines crossing the Stream, and that the volume, direction, temperature, etc., is only for a particular date, and under especial conditions of wind and weather.

"In regard to the results of the investigation of this last season's work I have been particularly interested in what I was expected to find; that is, the bifurcation of the Stream into warm and cold bands. The warm and cold bands have been accepted for so long a time as a fact, and have been reported by such reliable authorities, that there must have been different conditions of weather during *our* observations. I have already stated that our observations did not indicate anything of the kind. From the time we entered the Stream on line O (the first line run) until leaving it, the wind was fresh from the southwest, and the current and warm water was in a very narrow stream. Sir C. Wyville Thomson says, in his Voyage of the Challenger: 'In crossing the Gulf Stream in both directions the alternate bands or interdigitations of warm and cold water were very perceptible.' In a study of the surface temperatures obtained by the Challenger I do not see

any change in the Stream itself, but there are warm and cold streaks well inside, near the one hundred fathom curve. Our temperatures also indicate these latter.

"The U. S. S. Jamestown crossed the Stream in May, 1882, and the officers report having observed the cold bands, but they also state that when the cold surface water was observed it was during a perfect deluge of rain. I have often observed that a heavy fall of rain changed the temperature of the surface water several degrees, but the temperature at five and ten fathoms did not show any change.

"I have examined eight log-books of our men-o'-war who crossed the Stream in the month of June in the same general locality as in line O. The prevailing wind was southwest, and in no case was I able to find anything like a bifurcation. The force of the current, its direction and even temperature, is certainly very much influenced by the wind and weather. The prevailing wind along our coast, as far north as Hatteras, is southwest during the summer months, and this was the season in which our observations were taken. In my report for the season 1881 I gave the change of direction of the general course of the Stream owing to a temporary change of the direction of the wind.

"In reference to the temperatures below the surface, the isothermals show only cold water on line O, until nearing the Stream, when they descend gradually and in the Stream abruptly to their greatest depth.

"Instead of the warm Stream water thinning away as it was reported to do when spread out, at the time of our crossing the Stream it was not much over fifty miles in width, as shown by the current and high surface temperatures.

"The general temperature at the bottom off Savannah, in the Gulf Stream, the depth being four hundred fathoms, was 45°; and at eight hundred fathoms outside and beyond the current, 39½°. On line O, the temperature in the Stream, at four hundred fathoms, was as high as 55°, and 40° at eight hundred fathoms. On the southern side of the Stream the temperature, at four hundred fathoms, rose as high as 60°, and to 42° at eight hundred fathoms. Just north of the Stream the temperature at four hundred fathoms was 39½° to 40°.

"The isothermals remained at the same depths from the Stream to the Bermudas, with the exception of a slight rise near the islands.

"On the line from the Bermudas to Hatteras the isothermals were at the same depths as on line O, south of the Stream. As we entered the current off Hatteras they were not quite as deep, being 48°, 47°, and 44° at four hundred fathoms, and 39° at eight hundred fathoms. It would appear that the Labrador current does not pass under the Stream until near Hatteras, when it would naturally follow the one thousand fathom curve, and go under the Stream at this point as I suggested in my last report.

"The two lines last run give only the temperatures of the Labrador current. They correspond with those taken on line O inside of the Stream, the temperature at four hundred fathoms being 38½°."

Mention is made in the report of the great usefulness of the electric lights in sounding at night. These lights were run by a No. 4 Brush dynamo, the motive power being a small upright engine connecting by belt. The governor of the engine was arranged to give twelve hundred and fifty revolutions to the dynamo per minute. The two lights, of two thousand candle-power each, were hung from iron cranes lashed in the fore-rigging, and extending beyond the vessel's side so as to throw the beams of light around the sounding wire where it entered the water. When the vessel stopped for a sounding or a serial at night, the dynamo was started and run during the time of stopping only. Soundings and serials were then taken and the records kept on deck with as much ease as in broad daylight. The dynamo was situated about fifteen feet from the standard compass. At that distance, when running, it affected the compass about one-half a point, the compass returning to its normal condition when the dynamo was at rest.

All of the Mother Carey chickens that were in sight were attracted by the light, and after it had been in operation from twenty minutes to half an hour the water immediately underneath became crowded with squid and small fish.

Owing to the lateness of the season when the work began, Commander Bartlett made but two

trials with the Siemens apparatus, and then only to verify the readings of the Miller-Casella deep-sea thermometers.

Commander Bartlett acknowledges the aid of Lieut. G. W. Mentz, U. S. N., and Ensign H. S. Knapp, U. S. N., in the arduous work of the cruise, and in closing his report expresses the great regret that he feels in retiring from the command of the Blake and duty under the Coast Survey. This regret I fully share, in view of the loss to the Survey of the experience gained by this able officer in deep-sea investigations during his four years' service.

Statistics of the work are as follows:

Deep-sea soundings, number of lines run	4
Length of lines in nautical miles	1,800
Number of soundings with wire taken	61
Air temperatures observed, with dry bulb	241
Air temperatures observed, with wet bulb	241
Serial stations occupied	222
Water temperatures observed, surface	2,331
Water temperatures observed, intermediate	1,511
Water temperatures observed, bottom	61

As already stated, under the head of Section I, the charge of the hydrographic party on board the Blake was transferred by Commander Bartlett to Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, in August, 1882.

Hydrographic work executed by these officers in the Blake off the coast of Long Island will be referred to later in this section, and the deep-sea soundings between the Bahamas and Bermudas under the heading of Section VI.

Hydrography of eastern entrance to Long Island Sound.—In pursuance of instructions dated July 19, 1882, directing Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, then in command of the steamer Gedney, to make a hydrographic resurvey of the eastern entrance to Long Island Sound, work had been begun by that officer but a few days before the exigencies of the service made it expedient to transfer him to the steamer Blake, and to assign Lieut. H. B. Mansfield, U. S. N., Assistant Coast and Geodetic Survey, to the charge of the hydrographic party on board the Gedney. Lieutenant-Commander Brownson was relieved by Lieutenant Mansfield August 1.

Between this date and November 6, when the work was completed, an area of four hundred and ten square miles was sounded, the limits of the sheet comprising that portion of the eastern entrance to Long Island Sound which is known as Block Island Sound. The plane of reference for the soundings was established by observations at the tidal station on Block Island. Statistics of the work are:

Miles run in sounding	583
Angles measured	1,737
Number of soundings	7,509

The following-named officers served in the hydrographic party: Master C. McR. Winslow, U. S. N.; Ensign W. B. Caperton, U. S. N., and Midshipmen W. C. Canfield, R. S. Sloan, and William Truxtun, U. S. N. A report of the hydrographic work executed during the winter season by Lieutenant Mansfield, off the east and west coasts of Florida, will be found under the head of Section VI.

Tidal observations.—Observations of tides were begun at Block Island on July 27, 1882, with the same self-registering tide-gauge that had been used in 1879, and at the same station on the breakwater at the eastern end of the island. The record was kept up by the observer, Mr. J. M. Conley, throughout the winter, with but little interruption. It is proposed to keep this gauge in operation while the resurvey of Long Island Sound is in progress, and thus make Block Island the base of the tidal survey of that sound and the waters connecting with it, as it was formerly made the base for the tidal survey of Buzzard's Bay and Narragansett Bay.

Re-establishment of points of old triangulation and determination of new points from Watch Hill westward for the resurvey of Long Island Sound.—In order to furnish points for the topographic and hydrographic resurveys of the north shore of Long Island Sound from Watch Hill westward, Assistant S. C. McCorkle, under instructions of July 31, 1882, proceeded to that part of the coast, and having after careful search recovered six stations of the former triangulation, began observations for the determination of new points on the 23d of August.

High winds and smoky atmosphere retarded somewhat the progress of the work, but by the 9th of November, when field operations closed, it had been pushed far enough to furnish the determinations required. For the computation of results, Mr. McCorkle used Watch Hill–Mount Prospect (2)—a base line of the primary triangulation. Statistics of the work are as follows:

Number of stations occupied	18
Number of angles measured	233
Number of observations	2,340
Number of points determined	41

During the winter season, Assistant McCorkle was assigned to duty which will be referred to under the head of Section VIII, and towards the close of the fiscal year was directed to resume work on the shores of Long Island Sound.

Topographical survey of Fisher's Island, Long Island Sound.—The field-work assigned to Assistant Edwin Hergesheimer upon being detached from office duty towards the close of July, 1882, was a topographic survey of Fisher's Island, near the eastern entrance to Long Island Sound. Much of the month of August was occupied in erecting signals, determining heights, and in fixing the positions of beacons and spindles for the use of the hydrographic parties at work in the vicinity. As completed on the 9th of November, the survey included the whole area of Fisher's Island, and the small islands, Wicopesset, and the Hammocks to the east and north of it. Mr. A. E. Burton served as aid during part of the season. Statistics are as follows:

Length of shore-line, including creeks and ponds, miles	60
Length of roads, miles	14
Area in square miles (Fisher's Island)	4.36

Upon returning to the office Assistant Hergesheimer, after inking his topographic sheet, resumed drawing for the topographical manual. Towards the close of the fiscal year he was instructed to proceed to Noank, Conn., in anticipation of a resumption of field-work upon the northern shore of Long Island Sound.

Hydrographic resurvey of Fisher's Island Sound and New London Harbor.—Lieut. Richardson Clover, U. S. N., Assistant Coast and Geodetic Survey, having been assigned to the charge of the hydrographic party on board the Coast Survey schooner Palinurus, and directed to make a hydrographic resurvey of Fisher's Island Sound and New London Harbor, arrived in New London early in July. The Palinurus had been in the service of the Fish Commission of the State of Connecticut, and while the vessel was being refitted and docked, search was made by Lieutenant Clover for a rock reported off Watch Hill, between the buoys in the channel entrance to Fisher's Island Sound. This rock, which had been struck by the steamer Massachusetts, was found and located without delay, and a detailed "Notice to Mariners" respecting it was soon after issued by the office. Soundings were begun in the Thames River, above the navy-yard, on the 1st of August, the lines being run on ranges one hundred meters apart, and continued at this distance until reaching the Sound, when the distance was gradually increased to two hundred and fifty meters; the lines crossing these at right angles were two hundred meters apart. Care was taken to develop all shoals and rocks by special systems of lines.

In the course of the survey, which included two hydrographic sheets, extending from Goshen Point eastward to Stonington, the southern limit being Fisher's Island, some rocks were found very dangerous to navigation which were before unknown, the most important of which were Vixen Ledge, half a mile southeast of Pine Island, and a cluster of rocks and a ledge, each with less than thirteen feet of water, and directly in the track of vessels using Pine Island Channel.

Due publicity was given to the existence of these dangers to navigation by the issue from the office of a "Notice to Mariners."

The plane of reference for the soundings was obtained by observation with staff-gauges set up at New London, Noank, and Stonington; at New London a self-registering gauge was also established under Lieutenant Clover's direction. Early in December the formation of ice interfered with the progress of the survey and it was brought to a close. Following are the statistics of the work:

Miles run in soundings	444
Angles measured	5,721
Number of soundings	25,284

Efficient service was rendered in the party by Ensign L. K. Reynolds, U. S. N., Midshipman Harry Phelps, U. S. N., and by W. C. Willenbucher, of the Coast and Geodetic Survey Office.

Early in the winter Lieutenant Clover was relieved from the command of the Palinurus and ordered to duty in the office.

Towards the close of the fiscal year the survey was resumed in Stonington Harbor under the direction of Lieut. A. V. Wadhams, U. S. N., Assistant Coast and Geodetic Survey, with the aid of Ensigns Thomas D. Griffin and W. C. Canfield, U. S. N. Between June 12th and 30th, 1883, Lieutenant Wadhams reports the following progress:

Miles run in sounding	16
Angles measured	358
Number of soundings	1,888

Topographic resurvey of the north shore of Long Island Sound to the eastward of the Thames River.—In pursuance of instructions dated July 29, 1882, Subassistant W. C. Hodgkins began, early in the following month, a topographic resurvey of that part of the north shore of Long Island Sound which may be specially described as the north shore of Fisher's Island Sound east of Bluff Point.

With reference to the general aspect of this portion of the coast, Mr. Hodgkins remarks that it is very irregular, being deeply indented by coves and rivers which form a succession of peninsulas and islands. That the drift formation is the prevailing one, though there are occasional outcrops of rock in place, and that the presence of innumerable bowlders is the most characteristic feature of the surface, these bowlders being found especially along the shore where the gravel and sand have been washed from under and around them. When lying on shoal ground at a distance from the shore they form reefs dangerous to navigation. The salt marshes, though frequently found along the shores of the coves, especially near the mouths of the larger streams, are not extensive enough to be considered a feature of great importance on this part of the coast. At Groton Long Point Mr. Hodgkins observes that the marshes and sand ridges present a formation curiously similar on a small scale to the alternate marshes and ridges of Cameron Parish on the southwestern coast of Louisiana. As the eastern limit of the work is approached, the character of the shore suddenly changes from the rocky shores of Stonington Harbor to the sea-formed sand-spit known as Napatree Point, at the western extremity of which a low hill of drift formation is reached, and turning suddenly to the north the spit continues a mile and a half farther to the extremity known as Sandy Point, the southern point of entrance to Little Narragansett Bay. Old residents state that for many years this point did not change materially, but that more recently there has been a rapid growth to the northward. The gain in this direction has been nearly six hundred meters since the survey of 1839.

A prevalence of rain and high winds somewhat retarded the progress of the survey. At the 30th of November, when it closed for the season, the topography included the shore-line from Bluff Point to a point east of Stonington, the harbor and wharf lines of Noank, Mystic, and Stonington, both shores of Napatree Point, and the outer shore eastward to a point a mile east of Watch Hill. The statistics are as follows:

Shore-line surveyed, miles	65
Ponds and streams, miles	8
Roads (including railroads), miles	20
Area of completed topography, square miles	2

During the winter season Subassistant Hodgkins was assigned to field-service which will be referred to under the heading of Section VIII, and towards the close of the fiscal year received

instructions to prepare for the resumption of topographical work on the shores of Long Island Sound.

Topographic resurvey of New London and vicinity.—Field-work for the topographic survey in the vicinity of New London was begun by Assistant W. H. Dennis about the middle of August, 1882, the entire shore-line included in the sheet from Thames River entrance to a distance of about two miles and a quarter north of New London being first surveyed for the use of the hydrographic party, after which details of topography were filled in. These included the streets of the city of New London and the town of Groton. Unfavorable weather prevailed during the greater part of the season, there being but thirteen days available for field-work in September and but seventeen in October. By the 9th of December, when the season closed, the statistics presented were as follows:

Shore-line surveyed, miles	48
Roads, length of, miles	33
Area of survey, square miles	7

During the winter season, Assistant Dennis was engaged on office duty, and under instructions received towards the close of the fiscal year prepared for completing unfinished details of the New London work and for the prosecution of the survey to the westward.

Tidal observations.—Early in October, 1882, a self-registering tide gauge was established at Fort Trumbull, New London, Conn., and, under the direction of Lieut. Richardson Clover, U. S. N., Assistant Coast and Geodetic Survey, Sergeant E. Koch, stationed at the fort, was placed in charge. The record was kept up during the winter by the observer with but few interruptions. It will be important to continue these observations until the completion of the resurvey of Long Island Sound, New London being the principal port to which all others on the sound are referred in the tidal reductions and predictions.

Re-establishment of points of former triangulation, and determination of new points on the south shores of Long Island Sound, in the vicinity of Montauk Point and Gardiner's Bay.—For the use of the topographic and hydrographic parties engaged in the resurvey of the south shores of Long Island Sound, it became necessary to recover as many points of the former triangulation as practicable, and to determine a number of new points. This duty was accomplished by Subassistant C. H. Van Orden, who organized his triangulation party at Amagansett, Long Island, early in August, 1882, and starting from the bases, Gardiner's Island–Montauk light-house, and Gardiner's Island–Montauk (2), carried a series of secondary and tertiary triangles westward to Life-Saving Station No. 10, and northward to Gardiner's Island light-house, checking his determinations of new points as often as possible by the stations of the old triangulation, which he succeeded in re-establishing. Following the general course of the shore, the distance covered is about fifty miles. Work was closed for the season November 25. The statistics are:

Stations occupied, number of	30
Directions measured	1,593
Points determined	96

Duty subsequently assigned to Subassistant Van Orden will be referred to later in this section, and also under the heading of Section VIII.

Topographic and hydrographic resurvey of the eastern part of the south shores of Long Island Sound.—Assistant Charles Hosmer, having been directed to take charge of the schooner Drift, organized his party on board of that vessel towards the middle of August, 1882, and began a topographic and hydrographic resurvey of the east end of Long Island and of Gardiner's Island. Work in these localities was prosecuted until the 20th of October, when, in consequence of stormy weather, it could be continued to advantage no longer on this part of the Long Island coast, and Assistant Hosmer transferred his party to the western part of the Sound.

At the date just mentioned the topography and inshore hydrography of the eastern part of Long Island had been completed from Montauk Point light-house to a point about half way between Fort Pond Bay and Napeague Harbor; also the topography of Gardiner's Island, and the inshore hydrography of its eastern face from Gardiner's Island light-house to the southern part of Tobacco-lot Bay.

In the execution of the hydrography, Assistant Hosmer acknowledges the valuable assistance rendered by Master John C. Fremont, jr., U. S. N., and by Ensign A. F. Fechteler, U. S. N.

Statistics of this portion of the season's work will be included in those given later under the heading of this section with a report of the survey in the western part of the Sound.

Hydrographic resurvey of Gardiner's Bay and approaches, south coast of Long Island Sound.—In the plan for the resurvey of Long Island Sound, the hydrography of Gardiner's Bay and its approaches was assigned to Lieut. Edward M. Hughes, U. S. N., Assistant Coast and Geodetic Survey. His party was organized on board of the schooner Silliman, and had the use of a steam-launch loaned for the work by the Navy Department. Leaving New York July 24, 1882, Lieutenant Hughes anchored at Greenport, Long Island, July 29, and began work two days later.

In the course of the resurvey the need of it was not unfrequently shown by the changes which were found to have occurred during the lapse of from thirty-five to forty years. Some extracts from Lieutenant Hughes's report which bear upon this fact will be of interest:

"Marked changes in shore-line are frequently noticeable, as in the cases of Gardiner's Island, Ram Island, Long Beach Point, Cedar Point, and vicinity of entrance to Napeague Harbor. Particular attention is called to the great change in depth of water and channels found in that part of Gardiner's Bay lying to the southward of a line drawn from Acabomock Harbor to Ram Island, and to the westward of a line drawn from Ram Island to Goffe's Island. To the group of five menhaden oil-factories situated on the west side of the peninsula between Napeague Harbor and Gardiner's Bay, known as 'the promised land,' nineteen and one-half feet of water may be carried by vessels entering from Napeague Bay. * * * An increase in the number of buoys in this vicinity is desirable."

With reference to the character of the anchorages in the locality of the survey, Lieutenant Hughes remarks as follows:

"Excellent holding ground is to be found off Acabomock Harbor in all weather by anchoring in three and one-half to four fathoms, muddy bottom; anchoring too near the edge of the flats to the eastward should be avoided, as the anchor is apt to drag, owing to kelp on the bottom and its accumulating around the anchor.

"Vessels find excellent shelter from easterly winds in Bostwick Bay and Gardiner's Island bight to the southward, but the holding ground is not good and in strong westerly blows small fishing craft frequently drag up on the beach, on which account the anchorage in Gardiner's Island bight is avoided by fishermen.

"In anchoring in Sag Harbor entrance in northerly gales, Cedar Island light-house should by small craft be brought to bear N. $\frac{3}{4}$ E. (magnetic), where snug shelter may be found; and no vessel should anchor in mid-channel, as in northerly storms no part of Gardiner's Bay is as rough and uncomfortable as that part of the channel lying between Mashomuck Point and Cedar Island on an ebb tide."

For obtaining a plane of reference for the soundings, the principal tidal observations were made during the month of August at the tide-gauge established at Greenport, Long Island. Four auxiliary gauges were also established and connected with the principal gauge by special observations.

The work on the Gardiner's Bay sheet had been completed, including the surveys of Napeague Bay and Harbor and Three-Mile Harbor, and preparations had been made for beginning the hydrography of Greenport Harbor and Orient Bay, when instructions were received to close operations for the season. At the date of closing, November 9, the statistics show that the following amount of work had been accomplished:

Miles run in sounding	695
Angles measured for fixing position of sounding-lines	4,962
Number of soundings	26,485
Shore-signals established	97
Angles observed for location of shore-signals	691
Buoys located	12
Specimens of bottom obtained	37

Midshipmen Francis W. Kellogg and A. A. Ackerman, U. S. N., were attached to the party, and rendered service the efficiency of which is acknowledged by their commanding officer.

During the winter season Lieutenant Hughes was in command of the steamer Gedney and in charge of hydrographic work on the coast of Texas. This will be referred to under the head of Section IX.

Determination of the geographical position of the new observatory of Yale College.—At the request of Prof. H. A. Newton, of Yale College, the geographical position of the new observatory of the college, in course of erection on Winchester Hill, was determined by connecting it with the triangulation of the New Haven region. Acting Assistant J. A. Sullivan was charged with this duty, and, in pursuance of it, put up the signals needed, and occupied stations East Rock and West Rock, from which he determined Fort Wooster and a station, Winchester Hill, quite near the new observatory. Measurements with steel tape were made from Winchester Hill to the observatory, the proximity of valuable shade-trees not permitting direct observation from the stations occupied.

Two small observatories in the yard of North Sheffield College were also connected with the triangulation. Mr. Sullivan found that the station at West Rock was in danger of being lost, owing to the effect of fires made by visitors on the ledge, which cause the surface of the rock to crack and "shell off," so that the inch copper bolt marking the station was exposed for more than half its length. He inserted three half-inch copper reference-bolts at suitable distances in a ledge of solid rock noticeably lower than the one at the station.

Field-work was concluded October 20. The statistics are:

Number of stations occupied	6
Number of new points determined	8
Number of observations	850

After forwarding to the office his records and computations, Mr. Sullivan resumed office-work in the party of Assistant Henry Mitchell.

Determination of points for the resurvey of the north shore of Long Island Sound from the vicinity of Bridgeport, Conn., westward.—In accordance with an understanding had with the Shell-Fishery Commission of the State of Connecticut, in virtue of which the triangulation of the Connecticut shore of Long Island Sound from Penfield Reef westward to the State boundary was to be carried on so that the results would be available for the purposes of the Commission in the location of oyster-grounds under their jurisdiction, as well as for use in the hydrography of the Sound, Assistant Gershom Bradford, who had during the previous season executed work for the Commission and was in charge of such work at the beginning of the fiscal year, was directed early in July, 1882, to begin a triangulation near Bridgeport, Conn., and to carry it westward along the shore of the Sound to Captain's Island.

A sufficient number of points of the former triangulation near the shore upon which to start from not having been found, Mr. Bradford selected the line Tashua Hill–Bald Hill of the old primary triangulation as a base of operations, and by a careful reconnaissance succeeded in connecting the stations newly selected along the shore as far westward as Sheffield Island. Additional stations between Sheffield Island and Captain's Island were determined from the line Bald Hill–Stamford light-house. Station Round Hill of the primary triangulation could not be recovered, but a station was established there which can doubtless be checked in position ultimately from the old primary line Bald Hill–West Hills.

The latter part of the season being favorable, field-work was continued till January 16, by which time such results as were available for the purposes of the Fish Commission had been supplied to it. The statistics are:

Number of points determined	40
Number of angles measured	225
Number of observations	5,268

Mr. H. R. Garland served as recorder in the party.

During the remainder of the fiscal year, Assistant Bradford was occupied in the office-work

needed to complete his computations, and in preparing for the Fish Commission copies of his records and results.

Recovery and marking of triangulation points on the north shore of Long Island, between Hempstead Harbor and Horton's Point, N. Y.—For the purposes of the resurvey of Long Island Sound, it became desirable to re-establish as many stations of the old triangulation as practicable on the north shore of Long Island. This duty, upon that section of the coast between Hempstead Harbor and Horton's Point was assigned to Assistant F. H. Gerdes during the winter of 1882–'83. Mr. Gerdes arrived upon the ground in January, 1883, and though suffering from the infirmities incident to his advanced age and from the exposure due to the supervision of work in ground frozen and often covered with snow, he remained in the field until the middle of March, prosecuting the search at every available opportunity. A severe attack of illness occurring about this time, compelled his recall from field-service.

Topographic and hydrographic resurvey of the western part of Long Island Sound, in the vicinity of Throg's Neck.—The work of the party under the direction of Assistant Charles Hosmer, commanding the schooner Drift, in the eastern part of Long Island Sound, has already been referred to in this section, and mention made of the transfer of the party to the western part of the Sound towards the close of October. On the 1st of November Mr. Hosmer began a resurvey of the hydrography between Hart Island and City Island, and continued it till December 5, when extreme cold weather compelled a suspension of field operations.

During the winter, the Drift was laid up at the navy-yard, Brooklyn, in charge of Master J. C. Fremont, jr., U. S. N., and Assistant Hosmer was occupied in office-work.

Early in May, 1883, the work was resumed by Assistant Hosmer, in the Drift, with the aid of Ensigns H. C. Wakenshaw and R. P. Schwerin, U. S. N. By the 27th of June, the shore-line survey from Willets Point to Prospect Point on the Long Island shore, and from Throg's Neck to a point near Whortleberry Island, on the north shore, including the islands in the vicinity, had been completed; also the hydrography between Sand Point, Execution Rock, and Whortleberry Island on the east, to Throg's Neck on the west. Preparations were then made by Mr. Hosmer for the resumption of the resurvey in the vicinity of Greenport. Statistics to the close of the fiscal year are as follows:

Shore-line surveyed, miles	93
Roads, miles	5
Miles run in sounding	335
Angles measured	1,616
Number of soundings	13,978

Hydrographic resurvey of the approaches to New York Harbor.—In accordance with instructions issued towards the close of July, 1882, Lieut. Commander Eugene B. Thomas, U. S. N., Assistant, Coast and Geodetic Survey, having organized his party upon the steamer Bache, began early in August a hydrographic resurvey of the approaches to New York Harbor. This work was steadily prosecuted until early in November, when the advance of the season rendered it advisable to suspend operations afloat. Lieutenant-Commander Thomas reports the weather as exceptionally unfavorable during the time occupied by the survey. He had the aid of the following-named officers, whom he commends without exception for zeal and intelligence in the performance of duty: Master Frank A. Wilner, U. S. N., and Ensigns H. M. Witzel, J. M. Orchard, and C. S. McClain, U. S. N. The statistics of the season's work are:

Miles run in sounding	1,104
Angles measured	4,004
Number of soundings	18,932

Lieutenant-Commander Thomas was detached from the Survey November 25.

Series of tidal observations continued with self-registering tide-gauge at Sandy Hook, N. J.—On the 1st of July, 1882, Mr. J. W. Banford, who had been in charge of the self-registering tidal station at Sandy Hook for several years, resigned, and was succeeded by Mr. F. W. Shepheard. During

a violent storm on the 12th of September, the wharf upon which the tide-house stood was broken down, carrying the tide-house, tide-gauge, and the record for a number of days with it. After the storm subsided, the tide-house and gauge were recovered, repaired, and established upon a wharf which since then has been rebuilt and strengthened with new piles, so that there is now a fair prospect of a continuous record for some years to come. The loss of the record while the gauge was being put into working order again was partly remedied by staff observations.

Determinations of the force of gravity at Montreal, Canada, Albany, N. Y., and Hoboken, N. J.—Determinations of the force of gravity, both absolute and relative, were continued by Assistant Charles S. Peirce during the fiscal year. At the station Stevens Institute, Hoboken, a regular determination of the absolute force of gravity was made with the Repsold apparatus. Two new invariable reversible pendulums were oscillated; the same that were used at the stations in Washington. These pendulums were then transported to Montreal, Canada, and oscillated at the station selected with the permission of the authorities of McGill College in the basement of the College Observatory. Thence in September they were taken to Albany, where they were oscillated in the transit room of the Dudley Observatory.

In these experiments Mr. Peirce had the aid of Messrs E. D. Preston and F. B. Hall.

In February, 1883, the Stevens Institute Station, Hoboken, was reoccupied in order to continue the work of comparing the yard and the meter by means of reversible pendulums numbered 2 and 3, the latter being the yard pendulum.

Other determinations of gravity made by Mr. Peirce will be referred to under the heads of Sections III and VI.

In Appendix No. 19 is given a paper by Mr. Peirce which was intended for publication as one of the Appendices to my Report for last year, but was omitted for want of space. It relates to results for force of gravity obtained by him at Allegheny, Ebensburg, and York, Pa.

Hydrography off south coast of Long Island, and lines of deep-sea soundings in the vicinity of New York Bay entrance.—Upon the completion of the line of deep-sea soundings off Nantucket, reference to which has been made under the heading of Section I, Lieutenant-Commander Brownson was instructed to run a series of lines of soundings normal to the coast off the south shore of Long Island, at distances apart of from seven to ten miles, and far enough out to include the one-hundred-fathom curve. This duty was successfully accomplished in the steamer Blake between September 6 and October 11, 1882. At the date last named, when further work was prevented by bad weather, sixteen lines of soundings had been run. The Blake was then ordered to New York, where her commander prepared her for deep-sea sounding work between the Bahamas and the Bermudas. This will be referred to under the heading of Section VI.

The following-named officers attached to the Blake served in hydrographic duty during the season off the Long Island coast: Lieut. G. W. Mentz, U. S. N.; Masters Henry Morrell and Lucian Flynne, U. S. N.; Ensigns H. C. Wakenshaw, W. M. Constant, and Harry S. Knapp, U. S. N.

Upon the completion of her southern work in the spring of 1883, the Blake returned to New York and, under instructions issued April 16, took up deep-sea sounding work in the approaches to New York Harbor.

For the off-shore and deep-sea sounding work executed in the Blake during the fiscal year ending with June, 1883, Lieutenant-Commander Brownson furnishes the following statistics:

Length of lines in miles	1,671
Number of deep-sea soundings	191
Number of water temperatures (surface)	877
Number of water temperatures (intermediate)	346
Number of water temperatures (bottom)	159
Number of serial temperatures	52
Number of air temperatures (dry bulb)	756
Number of air temperatures (wet bulb)	711
Number of specimens of bottom preserved	3,477

For the inshore hydrography executed during the same period the statistics are:

Miles of soundings run	3,946
Number of soundings	4,024

Verification of hydrography for the Atlantic Coast Pilot.—For the purpose of expediting the publication of the third volume of the Atlantic Coast Pilot, embracing the coast between New York and Chesapeake Bay, Assistant J. S. Bradford was directed, in July, 1882, to organize a party and proceed to verify by actual inspection the sailing directions of so much of the work as had already been published, and the manuscript of those portions which were nearly ready for the printer. The schooner George M. Bache was assigned as a means of transportation for the party. Owing to unexpected delays in the repairs and outfit of the vessel, Assistant Bradford was unable to start upon his inspection duty till near the close of August. Proceeding then from Alexandria to Lower Cedar Point on the Potomac, a day was spent in examining the new beacons which had superseded the old spindles and buoys in that vicinity, and in verifying the depths across the "Kettle-bottoms." The Lower Machodoc River was next examined, and having subsequently put into Norfolk for water, the Bache was detained there by adverse winds till September 8, when she passed out of the Chesapeake and headed for Delaware Bay. Light winds and calms prevailed, and delayed the vessel till the 10th instant, when a heavy northeast gale came up; the sea rose with great rapidity, and about an hour before sunset the fore-topmast was carried away. The topmast and main-topmast were in imminent danger of sharing the same fate, but by extraordinary efforts were finally secured. At seven o'clock p. m. the wind suddenly shifted to east-southeast, blowing with great violence, and setting the ship directly towards the beach. No alternative remained except to crowd on all sail at the risk of foundering and try to get off shore. At this time the water was up to the tops of the lower berths on the berth-deck, and there was eighteen inches of water on the cabin and wardroom decks, the sea washing completely over the vessel, so that officers and men were most of the time up to their waists in water. For a while it seemed that nothing could prevent the beaching of the vessel, but gradually she began to claw off; the wind canted a couple of points to the southward, and finally Cape Henlopen was made, and on the afternoon of the 11th the Bache was anchored in the Breakwater.

While at anchor here a second gale sprang up from NW. by N., against which the Breakwater offered no protection. In this gale the best boat of the ship, while secured at the davits, was broken in two and dashed on shore, a mass of splintered timbers; all of the ship's provisions were ruined, and the delays thus occasioned for refitting and repair, together with the illness of Mr. Bradford, resulting from exposure, prevented the beginning of the hydrographic examinations contemplated in Delaware Bay till early in October.

These examinations included Salem Creek, "Joe Flogger" Shoal, and the banks and channels between Wilmington and Philadelphia, with such notes of changes and additions of aids to navigation as were required to complete Subdivision 15 (Delaware Bay and tributaries) of the Atlantic Coast Pilot.

Similar work was done in Chesapeake Bay after the arrrival of the Bache in Hampton Roads on the 2d of November. Data and material were collected for the revision of sailing directions and descriptions for the coast between Cape Henlopen and Cape Henry, and for the Chesapeake Bay and its tributaries, these localities being included in Subdivisions 16 and 17 of the Atlantic Coast Pilot. In February, 1883, field-work was closed, the Bache turned over to the care of a ship-keeper, and Assistant Bradford, proceeding to the office, took immediate charge of the work of preparing for publication the manuscripts of Subdivisions 16 and 17 of the Coast Pilot.

As organized for office duty, his party at the beginning of the fiscal year consisted of Mr. John W. Parsons, writer to the Coast Pilot, and Mr. John R. Barker, draughtsman and artist. Until the date of his detachment from the Coast Pilot division and transfer to the office of the disbursing agent, March 17, 1883, Mr. Parsons was engaged in completing the preparation for publication of the reprints of Subdivisions Nos. 2, 4, 5, and 6 of the Atlantic Local Coast Pilot; in a revision and rearrangement of a part of the "Table of Depths" for the Atlantic and Pacific coasts of the United States, and in making an index to Subdivision 15, Atlantic Local Coast Pilot. The manuscript of this subdivision was completed for the printer by Assistant Bradford towards the close of January, 1883. The Table of Depths is published as Appendix No. 7 to this Report.

Mr. John R. Barker remained as usual in charge of the etching and engraving of the coast and harbor views for the Atlantic coast. During most of the year he was employed on the views for Division D of the Atlantic Coast Pilot, but he rendered valuable service in retouching those

belonging to Division B (Boston to New York), and in re-engraving some views belonging to Division A (Eastport to Boston). These views were originally printed by what is termed the "graphic process."

Assistant Bradford, after the completion of Subdivision 15 of the Coast Pilot, gave his personal attention to the preparation of the Table of Depths for the printer, to proof-reading for the Coast Pilot, and to the compilation of a report upon Discrepancies in Nomenclature between the Coast Survey Charts and the publications of the Light-House Board for the Pacific coast.

On the 26th of May Mr. W. O. Jones was assigned to duty with Mr. Bradford, and served satisfactorily till June 30, when he was ordered to field duty.

The Table of Depths was finally completed on the 20th of June; the manuscript of Division C of the Atlantic Coast Pilot (New York to the Chesapeake) as far as and including Delaware Bay and River, has been printed, but only that portion relating to the New Jersey coast between New York and Delaware Entrance has been published; it is expected, however, that the manuscript descriptive of the coast between Cape Henlopen and Cape Henry will shortly be ready for the printer and that the publication of Subdivision 15, Delaware Bay and Tributaries, will not be longer delayed.

Leveling operations for connecting the Coast Survey reference mark at Albany, N. Y., with the primary triangulation station on Mount Mansfield, Vt.—In order to connect the levels of the northern line of Coast Survey triangulation with the tide level at Sandy Hook by way of the Hudson River and Lake Champlain, Assistant O. H. Tittmann was instructed, towards the close of August, 1882, to proceed to Albany, N. Y., and organize a party for running a line of levels from the bench-mark at that place to Burlington, Vt., and thence to the primary triangulation station on Mount Mansfield, Vt. He was also directed to obtain for purposes of comparison the canal levels between the Erie Canal and Lake Champlain.

In pursuance of this duty Assistant Tittmann carried a line of levels from the Albany bench-mark to Whitehall, at the southern extremity of Lake Champlain, and thence along the west shore of the Lake on the track of the Delaware and Hudson Canal Company's railroad as far as Putnam station, about thirteen miles north of Whitehall. In accordance with the general tenor of his instructions, which contemplated the determination of the relative elevations of selected points along the lake by its surface water level, Putnam station was adopted as the provisional terminus of the spirit-leveling, and gauges were established at this station and at Port Henry, Plattsburg, Rouse's Point, and Burlington. Observations on the stage of water were kept up at these gauges from November 4 to November 18. During this time the work of leveling down Mount Mansfield was begun, and continued until it was interrupted by the severity of the weather. A permanent bench-mark was established on the west side of the mountain on the Underhill trail about four hundred metres below the summit.

At the different points along the lake above mentioned, bench-marks were established and connected with the hydrographic reference-marks which had been fixed during the survey of the lake in 1873 and 1874; connection was also made at Fort Montgomery with that point on the water-sill of the fort which was used as a reference point for the observations conducted for a period of twelve years under the direction of the Corps of Engineers.

Messrs. J. W. D. Atkins and W. O. Jones served in the party as rodmen. Field operations were closed November 20. After depositing in the office the records and computations relating to the leveling work, Assistant Tittmann was assigned to duty, a report of which will be given under the heading of Section VI.

Primary triangulation across the State of New York for connecting the triangulation of the Hudson River and Lake Champlain with that of the survey of the Great Lakes.—The scheme proposed by Assistant C. O. Boutelle for the continuation of the triangulation across the northern part of the State of New York having been approved, he was authorized to take the field at the beginning of the fiscal year.

Five directions, at four stations, remained to be observed upon Hamilton Station; to obtain the three directions from Prospect and Helderberg Mr. Boutelle occupied these stations between the 6th of July and the 13th of August. At Prospect the work was greatly delayed by smoke.

At Prospect station the magnetic elements were determined by observations made during three days by Subassistant J. B. Baylor; similar determinations were also made by him at Otsego station in Cherry Valley. Station Pen Mount was occupied by Mr. J. B. Boutelle with the twenty-inch theodolite to obtain the directions needed to Mount Hamilton, and later in August Mr. Baylor occupied Tassel Hill for a similar purpose.

Before the occupation by the chief of the party of Prospect and Helderberg a reconnaissance was made by Mr. J. B. Boutelle under his direction, to determine the most available point intermediate between Fenner and Clyde, the latter point being one of the stations of the Lake Survey. The station finally selected was Howlett, near Syracuse, which makes a very good connection with the Lake Survey stations. With the selection of station Loomis, to the northward of the State survey station Gilbert, the scheme wasc ompleted. During September, station Fenner was occupied, and during October, station Florence, these two stations forming a quadrilateral with Loomis and Howlett. Early in November field operations for the season were closed.

On the 4th of September, Assistant Boutelle was appointed a member of the Advisory Board of Harbor Commissioners of Norfolk and Portsmouth, in place of Assistant Henry Mitchell, who had desired to be relieved from that service. Duty in this connection, and in the preparation of the records and results of his season's work, occupied him during the winter and early spring.

In May and June, 1883, the connection of the Coast Survey with the Lake Survey triangulation was pressed forwards to a conclusion by the occupation of Loomis station. Observations here were completed early in July, and preparations made for the occupation of Howlett. From Loomis the Lake Survey station Mannsville was found to be visible, thus giving a direct connection with the Sandy Creek base of that Survey. Preliminary computations from the observations obtained at Loomis indicate a close and satisfactory agreement of results at the junction of the two systems of triangulation; an agreement which is the more satisfactory since each system is an absolutely independent work, starting from bases widely separated on the Atlantic coast and on the Great Lakes, and carried on by independent methods, instruments, and observers.

Continuation of the triangulation of the northern part of the State of New Jersey.—Three stations were occupied by Prof. E. A. Bowser, Acting Assistant, during the summer and autumn of 1882, under instructions to push forward to completion, as far as practicable, the geodetic survey of the northern part of the State of New Jersey.

Observations were begun at Hamburg station, near the town of that name in Sussex County, on the 1st of July, the instrument being mounted upon a tripod thirty-two feet high, in order to see the station at Bear Fort. Signals were erected at stations Mount Olive, Culver's Gap, High Point, Bear Fort, and Bald Hill, and on July 7 a heliotrope was set up at Mount Olive. Every advantage being taken of favorable weather, the observations at Hamburg station were finished August 14, and the party was then transferred to Bear Fort, on the ridge so named, near the town of West Milford, Passaic County. Access to this station was extremely difficult, a road two miles long having to be cut over very rough conglomerate rocks from the main road to the station. Over this road the instruments, tents, and baggage had to be carried by hand to the summit of the ridge.

Preparations for observing had all been made when, on the 19th of August, the woods on the mountain were discovered to be on fire, and it was only after two days of the most strenuous effort that the fire was kept back from the camp. Some delay was thus occasioned in the work; observations were nevertheless completed on the 4th of September, and within a few days later the party was established at Bald Hill station, about seven miles to the northeast of Boonton, Morris County. Upon the completion of the observations at this station, October 31, field operations were closed.

Professor Bowser has presented the following statistics of the work, the numbers of sets given including observations upon secondary and tertiary as well as upon primary stations:

At Hamburg, number of sets of observations	71
At Bear Fort, number of sets of observations	56
At Bald Hill, number of sets of observations	85

Additions of topographical details to original sheets of the survey of the New Jersey coast between the Highlands of Navesink and Tom's River.—Examinations of the New Jersey coast between Tom's River and the Highlands of Navesink were made by Assistant C. M. Bache during the latter part of the summer and in the autumn of 1882, for the purpose of ascertaining the extent and character of the changes, natural and artificial, that had taken place along that portion of the coast since the earlier surveys, and of reporting upon the best method of obtaining surveys of the changes, by means of which, in connection with the existing original maps, the representations of the coast could be brought up to the present time.

The most rapid and effective method of completing the triangulation, topography, and hydrography of the area of that coast yet remaining to be surveyed was also investigated by Mr. Bache. This area is contained between a point about four miles south of Atlantic City and a point about two miles north of Hereford Inlet. The recommendations made in his report have been duly considered; and as a preliminary step to the adoption of a portion of them, the construction of a barge to serve as a floating camp was ordered, the barge Beauty, which had been in use several years for this purpose, having been condemned and sold.

In November Mr. Bache marked upon the original topographical sheets the new railroads constructed upon the coast in the vicinity of Tom's River, and surveyed the settlement Island Heights on that river; other details of topography of recent origin were added to the sheet as far north as Point Pleasant. The changes between Tom's River and the Highlands of Navesink were found to be limited to a narrow strip of land immediately on the coast. This is being rapidly built up to supply the demand for summer resorts. But few changes were found in the high-water line of the beach, except in the immediate neighborhood of the inlets, and in the strip of beach opposite the Highlands. Field operations were closed November 15. Duty subsequently assigned to Assistant Bache in the vicinity of Norfolk, Va., will be referred to under the heading of Section III.

Triangulation of Delaware Bay and River.—Assistant A. T. Mosman, having been charged with the duty of continuing the triangulation of the Delaware Bay and River in aid of the topographic and hydrographic surveys in progress there at the beginning of the fiscal year, established himself and party, by invitation of Assistant H. L. Marindin, on board the schooner Ready, lying in Smyrna Creek, and taking as a base, the line Cohansey light-house–Bombay light-house, extended the triangulation up the bay to connect with the work of Assistant McCorkle at the line Norny–Stoney, about two miles below Reedy Island light-house. It was extended also down the bay to the line Cross Ledge light-house–Mahon light-house, determining all of the signals erected by the hydrographic parties of Assistant Marindin and of Lieut. H. B. Mansfield, U. S. N., Assistant, Coast and Geodetic Survey.

As the work advanced down the bay, the party was transferred to Lewes, Del.; Cross Ledge light-house, and Brandywine Shoal light-house, screw-pile structures on shoals in the middle of the bay were occupied, and also the shore light-houses at Mispillion Creek and Cape Henlopen. By August 24 all of the stations required for the topographic and hydrographic parties on the river and bay had been determined, including a number of new points near Cape May and Lewes, and some points on Rehoboth Beach. All of the principal stations were securely marked. The statistics are:

Number of points determined	60
Number of stations marked	20
Number of angles measured	3,338

Special mention is made by Assistant Mosman in his report of the accurate and efficient service rendered by Mr. W. B. Fairfield, attached to the party as extra observer.

Duty assigned to Assistant Mosman later in the season will be referred to under the heading of Section III.

Physical survey of Delaware Bay and River.—The special investigations called for in the progress of the physical survey of Delaware Bay and River have already been referred to in Part I of this report under the heading "Physical Hydrography." These investigations have been made under the immediate direction of Assistant Henry Mitchell. As a member of the Mississippi River Commission, and of the U. S. Advisory Councils of the State of Rhode Island, and of the cities of

Philadelphia and Boston, Mr. Mitchell has not unfrequently been called away from the regular work of the Coast and Geodetic Survey, but has devoted much time to the study of the estuary of the Delaware. His conclusions, as deduced from the results of the recent surveys, are stated in Appendix No. 8.

In the harbor of Philadelphia, the location of port-warden lines is a problem complicated by the artificial changes on the city front; in the study of this subject so that the lines may be located in a way to balance as nearly as possible conflicting interests, the United States Advisory Commission found it necessary to avail itself of the experience and personal knowledge of the river acquired during the conduct of the physical survey by Assistant H. L. Marindin, who had been on duty with the party of Assistant Mitchell for several seasons.

Application having been made to me by the Commission for his detail as consulting engineer, the request was promptly complied with.

With reference to the elaborate comparison of the recent survey of the river and bay with that made by the Coast Survey forty years ago, Mr. Marindin finds that these forty years discover no fundamental changes but a complicated shifting of the shoals, and that while the mean depth for any given space greater than a square mile is rarely changed, the contours are all found out of register when one chart is placed over another, and in many cases the change in the course of the channel shows how very essential the resurvey had become in the interests of navigation.

In the office-work of his party Mr. Mitchell had the aid of Assistants Marindin and Granger during the intervals between their field-work. Mr. J. A. Sullivan, for many years an Assistant in the Coast and Geodetic Survey, was employed continuously in the party, except during a short detail for field-work, and almost exclusively upon the critical studies of sections, &c., referred to above.

Hydrographic resurvey of Delaware Bay and River.—The arrangement referred to in my last annual report, by which the hydrographic resurvey of Delaware Bay and River was carried on by Assistant H. L. Marindin, working in connection with a naval officer in charge of a separate party, remained in force during the season beginning with May, 1882. At the opening of the fiscal year Mr. Marindin, with his party on the schooner Ready, was actively engaged in the hydrography of that portion of the river between Collins' Beach, on the Delaware shore, and the mouth of Stow Creek, on the New Jersey shore. Bench-marks for tidal reference were established at Bombay Hook light-house, close to the tide-gauge at the mouth of Duck Creek, and all of the soundings on the hydrographic sheet were referred to the plane of mean low water as brought down from the gauge at Collins' Beach. About the 18th of July, the first-named sheet having been completed, work was begun upon a sheet with limits on the Delaware shore from Bombay Hook Point to Mahon's River light, and on the New Jersey shore from the mouth of Cohansey Creek to near Dyer's Cove. Tidal observations for plane of reference between Duck Creek and Leipsic Creek, where a tide-gauge had been established, were made, and later in the season a gauge was put up at Sea-Breeze Wharf, on the New Jersey side of the bay, and referred to Duck Creek to obtain the same plane of reference for the east side of the bay.

This hydrographic sheet was completed October 11; and an unfinished hydrographic sheet having been transferred to Mr. Marindin by Lieutenant Osterhaus, U. S. N., commanding the steamer Endeavor, some progress was made with it, but the weather being now very unfavorable for further operations, the work was suspended for the winter. The statistics are as follows:

Number of tide-gauges established	6
Miles run in sounding	690
Angles measured	4,740
Number of soundings	28,357

Subassistant W. I. Vinal was attached to the party from June 1 till August 15, when he received instructions for topographical duty, reference to which will be made later under the heading of this section. Ensign E. M. Katz, U. S. N., was a member of the party during the whole of the season. Midshipmen John A. Dougherty and L. S. Van Duzer, U. S. N., were attached to it, the latter from August 22 and the former from the first part of October. Mr. Marindin's report

makes acknowledgment of his appreciation of the efficient co-operation of these officers in both field and office work.

Hydrographic resurvey of Delaware Bay and River.—At the beginning of the fiscal year Lieut. H. B. Mansfield, U. S. N., Assistant, Coast Survey, commanding the steamer Endeavor, was in charge of one of the hydrographic parties engaged in the resurvey of Delaware Bay and River. On the 1st of August, 1882, he was relieved by Lieut. Hugo Osterhaus, U. S. N., Assistant, Coast Survey, who continued the work until the suspension of operations in November. The work upon one hydrographic sheet had been completed; the next one undertaken included that portion of the bay between Arnold's Point and Sea-Breeze Wharf; a third sheet, extending from Deep-Water Point to Egg Island, was then taken up and partly finished, but laid aside to execute the hydrography at Delaware Entrance, in the vicinity of Cape May. This was finished on the 13th of November, when the working season closed.

In the course of the survey, as opportunity offered, examination was made of dredged channels and ledges in Delaware River. These examinations included Schooner Ledge, a dredged channel through Cherry Island Flats, and a dredged channel near New Castle, Del.

The statistics of the hydrography executed are:

Miles run in sounding	984
Angles measured	5,078
Number of soundings	27,105

Ensigns W. H. Allen and E. N. Fisher, U. S. N., were attached to the party during the season; Ensign John T. Newton, U. S. N., joined it after the 15th of August. About the close of November, the Endeavor, Lieutenant Osterhaus commanding, was taken to Norfolk, Va., to be prepared for work off the southern coast, which will be referred to under the head of Section V. Soon after the arrival of the steamer in Norfolk, Lieutenant Osterhaus was relieved in command by Lieut. John T. Sullivan.

Resurvey of topography in the vicinity of Cape Henlopen, Del.—That portion of the resurvey of the shores of Delaware Bay in the vicinity of Cape Henlopen was committed to Subassistant W. I. Vinal, by instructions dated August 23, 1882.

Mr. Vinal remarks in his report that the most noticeable changes in the topography in the vicinity of the cape are:

(1) The closing of the entrance to Slaughter Creek; (2) the extension northward of the peninsula separating Lewes Creek from the ocean; (3) the change in position southward of the high sand-hills west of Cape Henlopen light-house; (4) the establishment of a summer resort at Rehoboth Beach, about seven miles below Lewes; (5) the interruption of the continuity of Lewes Creek in several places by drifting sands, and the connection of the separated parts by canals and ditches.

At high tides, when the wind is easterly, the marshes in this vicinity are completely submerged; this is the case also with the large sandy area just south of Cape Henlopen.

The resurvey was completed November 30. It included on one sheet, scale 1-20000, the topography for about three miles inland from Slaughter Creek (now closed) on the shore of the bay to the Beacon, and thence on the ocean shore to Thompson's Pond or Silver Lake, just south of Rehoboth. The statistics are:

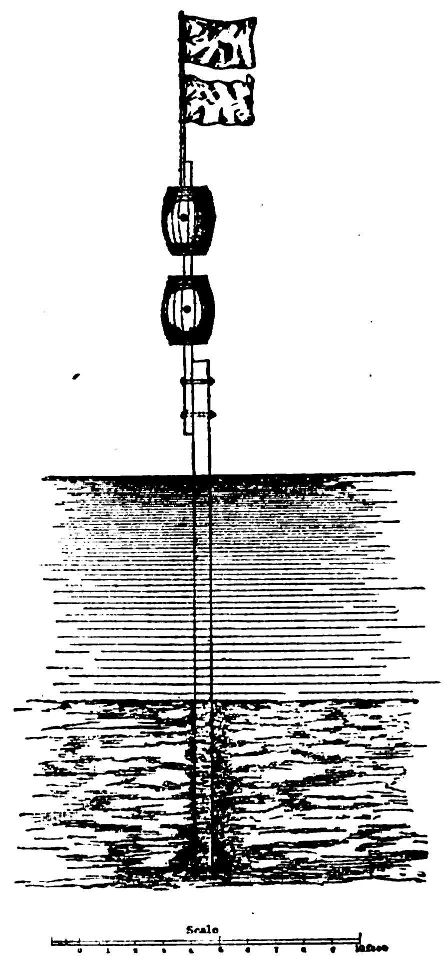
Miles of shore-line surveyed, ocean and bay	20
Miles of shore-line surveyed, large creeks	31
Miles of shore-line surveyed, small creeks	52
Miles of shore-line surveyed, ponds	11
Miles of shore-line surveyed, marsh outlines	75
Miles of shore-line surveyed, ditches on reclaimed marsh	25
Main roads, miles	33
Secondary roads, miles	39
Railroads, miles	10
Streets (Lewes and Rehoboth), miles	9
Area surveyed in square miles	30

During the winter Mr. Vinal was engaged on office duty, and toward the close of the fiscal year was ordered to topographical duty on the coast of Maine.

Continuation of the hydrographic resurvey of Lower Delaware Bay.—In pursuance of instructions issued towards the close of April, 1883, Lieut. G. C. Hanus, U. S. N., Assistant Coast Survey, assumed command of the steamer Arago, and having prepared her for service, proceeded in her to lower Delaware Bay to complete the hydrography of that locality. The work was in active prosecution during the last month of the fiscal year. Up to June 30, 1883, the statistics are as follows:

Miles run in sounding	301
Angles measured	2,938
Number of soundings	12,732

The following-named officers were attached to the party: Master W. G. Cutler, U. S. N.; Ensigns E. F. Leiper and G. R. French, U. S. N.



Lieutenant Hanus has applied to the setting of hydrographic signals a method frequently adopted in sinking piles in sand or mud covered by water. The pole intended to be put down as a signal has fastened to it a gas-pipe nozzle. This pipe should be long enough to reach the surface of the water when the signal is down. It is attached to the spar or signal by split rope-yarns, and steadied in line by nails driven on either side. When the end of the signal rests on the bottom, water is driven through the pipe by means of a force-pump; a hole is thus excavated in the sand into which the end of the signal sinks, and when the needed depth is reached, the force-pump being withdrawn, the sand packs round the lower part of the signal. To this part flanges or projecting pieces are usually secured before the spar is put down so as to obtain a stronger hold.

In deep water a pine spar needs guys on its head to steady it in an upright position, and the weight of a man or two hanging on to sink it. Oak or other heavy woods will go down by their own weight or a very little additional force at the rate of about one foot per minute in ordinary sand. When the pole is well embedded in the sand the gas pipe can be withdrawn. Signals of this description can be placed in any depth of water up to about fifteen feet. The bottom must be sandy or muddy, and the greater the depth the smoother must be the sea while the pole is being put in position.

Topographic resurvey of the New Jersey shore of Delaware Bay continued.—At the beginning of the fiscal year Assistant R. M. Bache was in the field with his party, engaged in carrying the topographic resurvey of the New Jersey shore of Delaware River and Bay from Pennsville southward.

Mr. Bache remarks in his report that the symmetrical delineation of the shores, if regarded as forming a continuous map, required the topography to be carried well inland over the convex sweep of the shore at Finn's Point, and that with this exception a very small margin of topographical delineation was taken, that below Elsingborough Point being simply designed to show clearly where the diked-in arable lands suddenly cease and wild marsh begins, and below that to correct, as it does in some places, the imperfect representation on the old chart of the mouths and lower reaches of some well-known creeks.

By the 1st of December, 1882, the survey had been carried from Pennsville to Round Island, below Fishing Creek, called Stony Inlet in the earlier survey. Field work was then closed for the

season. The statistics of the topography, as shown upon three sheets, with scales of 1–5000, 1-10000, and 1–20000, respectively, are:

Shore-line surveyed, miles	77
Streets and roads, miles	66
Area in square miles	13

During the winter Assistant Bache was engaged in office-work, and in May, 1883, received instructions to proceed to Salem, N. J., and make preparations for continuing the topographic survey from the close of his work of the previous season southward. He was thus occupied at the end of the fiscal year.

Continuation of the topographic resurvey of the west shore of the Delaware River and Bay from New Castle southward.—Upon the west shore of the Delaware River the topographic resurvey was resumed at New Castle, Del., by Assistant C. T. Iardella, in June, 1882. From New Castle to Reybold station, near the cove of that name, there is but little rising ground, and twenty-feet curves sufficed for its delineation. From Reybold station to Bombay Hook light, where the work terminated for the season, the country is entirely flat and the greater portion of it is marsh covered with water at half-tide.

Some of the distinguishing features of the creeks surveyed in the progress of the work are thus reported by Mr. Iardella:

"Saint George's Creek.—This creek is entirely closed at its entrance by flood-gates and banks. There are innumerable ditches to drain the water from the meadows into the creek.

"Augustine Creek is very narrow at its entrance; vessels cannot enter on account of the bridge about half a mile long built on piles driven into the marsh. I found it difficult to get my boat to the bridge, the entrance being nearly bare at low water, but after passing the bridge about one hundred feet nearly fourteen feet of water can be had at high tide for some ten miles.

"Appoquinimink Creek is one hundred and forty meters wide at its entrance, and is navigable to Odessa, a steamer making three trips a week from that place to Philadelphia. Six feet of water can be carried from the entrance of the creek to the main channel in Delaware River.

"Blackbird Creek, at its entrance, is one hundred and forty meters wide, and is navigable for vessels drawing six feet for nearly ten miles.

"Duck Creek is one hundred and fifty meters wide at its entrance, and has an average width of seventy-five meters to Smyrna. Vessels drawing seven feet can readily pass over the outer bar at high tide; from the entrance good water can be carried to Smyrna."

Mr. Iardella states that Pea Patch Island is increasing in size owing to the large quantities of mud that are dumped on the western shore from the wharves and entrances of the locks of the Delaware and Chesapeake Canal. A flat extends from the island to the western channel, a distance of three hundred and eighty meters. Bold water can be found on the eastern side along the shore for the whole length of the island.

The following statistics are reported for the field-work which closed December 5, and which was shown upon two topographic sheets, scales 1–10000 and 1–20000 respectively:

Miles of shore-line surveyed	32
Miles of low-water line	24
Miles of roads	37
Miles of marsh-line	27
Miles of ditches	42
Miles of streams	1
Miles of creeks	4
Miles of railroad	7
Area in square miles	13

Assistant Iardella was occupied in office work during the winter. He will begin the extension of the topographic resurvey southward toward Delaware Entrance at the opening of the fiscal year.

Reconnaissance and extension westward of the triangulation of the State of Pennsylvania.—The continuation to the westward of the triangulation of the State of Pennsylvania was committed to Professor Mansfield Merriman, Acting Assistant. He took the field July 1, 1882, starting from the line Gov. Dick–White Horse. The first station occupied was Gov. Dick, a point about six miles south of Lebanon, Lebanon County. Work here was finished August 5, and the party moved to station White Horse, at which a tower thirty-five feet high had been erected for the support of the instrument. The observations at White Horse were completed August 31. Measurements of a single angle being necessary at stations Blackspot, near Reading, and Smith's Gap, about fifteen north of Allentown, these two stations were occupied between September 1 and 21. During the remainder of the season, which closed October 11, four stations were visited to examine their marking; at three of these no station marks had been established, the general locality only having been determined by previous reconnaissance. Professor Merriman had their positions located and carefully marked. He reports that for the due development of the triangulation northward a special reconnaissance is desirable. Statistics of the work are as follows:

Positions of stations determined (primary)	14
Secondary stations (spires, steeples, &c.) determined	44
Number of measurements of angles	1,613

The records of the work have been transmitted to the office.

Determination of boundary line between Pennsylvania and West Virginia.—In compliance with a request from the Joint Commission of the States of Pennsylvania and West Virginia for the detail of officers of the Coast and Geodetic Survey to execute the work of tracing out the boundary line between Pennsylvania and the "Pan Handle" of West Virginia, Subassistant C. H. Sinclair was directed in April, 1883, to proceed with Col. James Worrall, the chairman of the Commission, to Pittsburgh, and to attend the meeting held there of the Joint Commissioners, in order to be fully informed of their views, and to give such information in regard to the mode of tracing and marking the boundary line, and the degree of accuracy which I deemed useful and practicable, as might be called for by the conference.

Instructions subsequently issued directed Mr. Sinclair to run the meridian line required, taking offsets to such of the old monuments as might be found. Subassistant C. H. Van Orden was assigned to duty with the party in order to execute the topography in the immediate vicinity of the monuments.

The work was making good progress at the date at which this report closes.

SECTION III.

MARYLAND, VIRGINIA, AND WEST VIRGINIA, INCLUDING BAYS, SEAPORTS, AND RIVERS. (SKETCHES NOS. 1, 4, 5, AND 6.)

Determinations of gravity by pendulum experiments at Baltimore and Washington.—In continuation of the work of the gravitation party previously authorized, Assistant Charles S. Peirce was directed at the beginning of the fiscal year to make comparative observations of gravity between Baltimore and Washington. This duty occupied the greater part of the month of July. Instructions then issued to Mr. Peirce involved gravity determinations at stations already mentioned under the heading of Section II. Upon his return to Washington in October, the work of measuring the pendulums used during the summer was continued and completed; the observations for the flexure of the Baltimore piers were finished, and the installation of a pendulum station at the Smithsonian Institution was begun. A stone structure having been erected for the pendulum support, two new invariable reversible pendulums were swung here and also at the Coast and Geodetic Survey Office. As already mentioned under the heading of Section II, the same pendulums were oscillated at the stations in Montreal, Albany, and Hoboken.

In this work Messrs. E. D. Preston, Carlisle Terry, jr., and Robert A. Marr, aids in the Survey, assisted Mr. Peirce. He gave instruction and general supervision to the parties of Messrs. Smith,

Preston, and Marr, referred to in Part I of this Report under the heading "Determinations of Gravity."

Mr. Peirce devoted such time as could be spared from field operations to office work. He read proof for papers relating to gravity determinations; prepared for publication a report on the pendulum work at three stations, Allegheny, Ebensburg, and York, in Pennsylvania; prepared a memoir on the spectrum meter; edited the report of the pendulum conference, and prepared a memoir on the effect of the flexure of pendulums themselves.

In pursuance of instructions dated April 23, 1883, Mr. Peirce left for Europe in May in order to make for the Coast and Geodetic Survey certain observations necessary for completing the connection of the American and English pendulum work and to obtain some additional pendulum apparatus of special construction. He is still abroad upon this duty at the date of closing this report.

Observations of the Transit of Venus at Washington, D. C.—The Transit of Venus of 1882, December 6, was observed at Washington by Assistants Charles A. Schott and B. A. Colonna. The place of observation, selected by Mr. Schott, was Fauth's observatory, at the southeast corner of First street west and B street south. Elevation of station above the sea, about 20 feet; geographical position as follows: Latitude, 38° 53′ 23″.2 north; longitude, 77° 00′ 33″.5 west from Greenwich.

Through the kindness of Mr. Fauth, Assistant Schott had the use of a new equatorial of his construction. It is driven by clock-work, and has an aperture of 15.25 centimeters (6 inches) and a focal length of 2.5 meters (8.2 feet). For the morning observation it was used with a magnifying power of 102, and for the afternoon observations with a power of 127. Full aperture was used in connection with a solar eye-piece, the prism of which deflected so much of the sun's heat and light that a light shade-glass sufficed for the protection of the eye. Dr. J. G. Porter, of the Computing Division, recorded time for Mr. Schott.

Light clouds prevailed during the day, with an atmosphere quite unsteady at times. The first contact was lost by clouds, and of the last contact the observation was uncertain on account of the extreme atmospheric tremor. The two interior contacts were satisfactorily observed. Full details are given in Assistant Schott's report, which appears as part of Appendix No. 16.

In this Appendix is included also the report of Assistant Colonna, who observed the Transit at the same station, with a reconnoitering telescope by Plossl, having a clear aperture of 9 centimeters (3.5 inches) and a focal length of 0.96 meters (38 inches). Mr. Colonna obtained observations of the two internal contacts and of the last contact.

Continuation of the detailed topographical survey of the District of Columbia.—The detailed topographical survey of the District of Columbia was carried on continuously during the fiscal year by the party in charge of Assistant John W. Donn. The area surveyed embraces some of the most intricate and difficult parts of the topography.

In accordance with the request of the Engineer Commissioners of the District, operations during the early part of the fiscal year were chiefly directed to the survey of the region over or under which the extension of the Washington aqueduct has been projected for the additional water supply; that is, from Rock Creek Valley to the distributing reservoir west of Georgetown. In October, 1882, this work was finished and a tracing was furnished to the Engineer Commissioners. This tracing covered the line of the proposed aqueduct from its western extremity to Smith's Valley, the site intended for the new reservoir, to the east of the line of Sixth street (northwest) extended.

Work was then resumed in the valley of Rock Creek, where during the cold weather a shelter was afforded which permitted the plane-table to be used almost without interruption from the winds. Another winter's work, Mr. Donn thinks, will advance the survey to the crossing of the Milkhouse Ford road, beyond which the hills are comparatively bare and less abrupt. During the months of May and June the work was carried over the open country east of Rock Creek, between Seventh street and Fourteenth street roads, and on the eastern border of the site of the new Observatory.

A map submitted by Assistant Donn with his report shows the area completed at the close of the fiscal year. Upon the scale of the survey, 1–4800, the area covered during the year was about five square miles; the length of roads measured twelve miles, and of creeks fifteen miles.

Assistant D. B. Wainwright aided in the work and showed great interest in its development.

Examination of the monuments of the Trial Base Line at Fort Myer reservation, Virginia.—It having been reported that the monuments at the ends of the Trial Base Line established in 1879 at the military reservation of Fort Myer (then Fort Whipple), in Virginia, were in need of repair, and perhaps of resetting, Assistant H. G. Ogden was directed in May, 1883, to examine their condition. The brick-work of both monuments was found to need repointing, and water had settled in the sight-tubes for the underground marks. These tubes can, however, be readily kept free from water by the introduction of additional drain pipes. The south monument was perpendicular and unchanged in position; the north monument had a slight inclination, due, as Assistant Ogden concludes, to the combined action of frost and unequal compression of the earth-filling. No possible movement of the monuments on their foundation can affect the underground marks, but steps will be taken to secure for the surface-marks the utmost degree of stability.

Special survey for the Fish Commission near the Great Falls of the Potomac.—Application having been made by the United States Fish Commission for the detail of an officer of the Coast and Geodetic Survey to make a special topographical survey in the vicinity of the Great Falls of the Potomac, Assistant Eugene Ellicott was directed to report to the Commissioner, Prof. S. F. Baird. Having done so on the 17th of November, 1882, he began the survey soon after on a scale of 1–600, or fifty feet to the inch, running contour lines one foot apart. The work covered a part of the bed of the river, which is bare, or nearly so, at low stages of water. Unfavorable weather, with temperatures seldom above the freezing point and rocks incrusted with ice, delayed progress; but the field and office work required was completed about the middle of January, and the topographical sheet was then turned over to the Commission.

Other field duty to which Assistant Ellicott was assigned during the year is referred to under the heading of Sections I and VI.

Continuation of topographic survey of the south shore of Hampton Roads, between Craney Island and Nansemond River.—Field-work in continuation of the topographic survey of the south shore of Hampton Roads, between Craney Island and Nansemond River, was begun by Assistant Charles M. Bache early in May, 1883, and continued until the party was disbanded under instructions on the 6th of June. The topography delineated is shown on one field sheet, scale 1–10000, for which the following statistics are given:

Roads surveyed, miles	47
Creeks, miles	17
Area of topography, square miles	6

Mr. J. H. Turner, acting aid, rendered acceptable service in the work.

Duty assigned to Assistant Bache on the New Jersey coast is referred to under the head of Section II.

Observations of currents at stations near the entrance of Chesapeake Bay and thence southward.—Under instructions issued in February, 1883, Master J. C. Fremont, jr., U. S. N., Assistant, Coast Survey, having organized his party on board the schooner Drift, proceeded to occupy a series of current stations along the eastern coast of the United States, beginning near the entrance to Chesapeake Bay and passing thence to the southward. The additional stations provided for in the instructions were at points near Cape Hatteras, Cape Fear, and Cape Lookout; in the Florida channel normal to the Gulf Stream at Cape Florida, and at Jupiter Inlet.

During the occupation of the first station, about 80 miles northeast of Cape Henry, the port anchor was lost in a heavy gale and rough sea, compelling the return of the Drift to Norfolk. This was on the 28th of February, after the station had been occupied twelve hours. The second station, occupied March 28 and 29, was about 43 miles southeast of Cape Henry; the third off Cape Lookout, the fourth off Cape Fear, these two stations being occupied April 12 and April 19, respectively.

Reference will be made, under the head of Section VI, to the current stations occupied by Master Fremont off the eastern coast of Florida.

Determination of the longitude of the University of Virginia, Charlottesville, by exchange of telegraphic signals with Washington, and of the latitude of the Charlottesville station.—As stated in my last annual report, the preliminary arrangements for the determination of the longitude of a station

at the University of Virginia, Charlottesville, were in progress at the beginning of the present fiscal year.

Subassistant C. H. Sinclair had general charge of the work, and directed personally the construction of an observatory and the building of a pier at the station selected in the grounds of the University. The observatory was of a more substantial character than is usual with the temporary stations of the Coast and Geodetic Survey, it being intended for use subsequently by the McCormick Observatory.

Subassistant F. H. Parsons was directed to report to Mr. Sinclair, and was placed in charge of the details of the work at the Coast and Geodetic Survey station in the grounds of the Naval Observatory, Washington.

Longitude signals were exchanged by telegraph between Messrs. Sinclair and Parsons on the nights of July 15, 24, and 25. The observers then changed stations, and longitude signals were again exchanged on the nights of July 27, August 7, 10, and 11. The latitude of the station in Charlottesville was determined by Subassistant Parsons, seventy-nine observations on sixteen pairs of stars being made for this purpose. By the measurement of a short base and the observation of the necessary angles, the position of the station in latitude and longitude was referred to the dome of the University.

Other duty assigned to Mr. Sinclair is mentioned under the heads of Sections II and XV, and under Sections VIII, XIII, and XIV will be found statements of work executed by Mr. Parsons.

Connection of the astronomical station at the University of Virginia with the primary triangulation.—Stations Humpback and Jarmans of the primary triangulation in Virginia were occupied in March, 1883, by Subassistant C. H. Sinclair, in order to connect the astronomical station at the McCormick Observatory, University of Virginia, with the scheme of triangulation between the Maryland and Georgia base lines.

Tripod signals were erected at the necessary points, and all of the observations needed (138 in number) were obtained in the course of about two weeks.

Reconnaissance, triangulation, and hypsometric observations in the region about Washington, D. C., for the construction of a general map.—Surveys for the completion of the sheet of topography previously undertaken by Mr. H. F. Walling, and referred to in my last annual report, were begun by him in July, 1882, and the map substantially completed as far west as the North Mountain.

No trustworthy maps of the territory being available, special surveys were required of all the topographical features to be represented. Accordingly traverse surveys were made of all the roads; of the railroads where the engineer's plans were unattainable, and of the streams throughout the entire county of Berkeley, West Virginia, and of those portions of Frederick, Clarke, and Loudoun Counties, Virginia, lying north of the parallel of 39° 4′ north latitude. Distances along the roads were measured by odometer; directions of roads ascertained by the surveyor's compass; the streams were also traversed, a chain being run along the larger creeks and rivers, while the minor streams, requiring less precise measurement, were located between road crossings by pacing. Traverses were also made up many mountain ravines and along or near the tops of ridges and spurs, advantage being taken for that purpose of wood roads whenever practicable. The positions of about thirty triangulation points have been fixed from time to time at convenient localities among these surveys, and the traverses have been carefully connected with them. Frequent observations with the aneroid barometer were made, a stationary record having been kept on working days every hour. The approximate elevations thus obtained along roads at summits, stream crossings, along ridges and valley lines having been marked in position, contour lines with vertical intervals of one hundred feet were traced by interpolation upon the map.

Progress was made also in the field-work required for the map of Washington and vicinity. New surveys were undertaken for the delination of all topographical features, except those shown upon plane-table sheets in the archives of the Coast and Geodetic Survey.

The scale of publication for the proposed maps will be 1–100000.

Mr. Walling was efficiently aided in his work by Messrs. N. B. K. Hoffman, R. H. Brown, J. A. Miller, and T. B. Mann.

Reconnaissance for the extension of the primary triangulation near the thirty-ninth parallel westward in West Virginia, Ohio, and Kentucky.—The reconnaissance referred to in my last annual

report as having been begun by Assistant A. T. Mosman for carrying the scheme of primary triangulation near the thirty-ninth parallel toward the Ohio River was resumed by that officer in September, 1882. Starting from the line, Piney–Pigeon, in the Kanawha region of West Virginia, Mr. Mosman examined a country cut into deep ravines through which flow the numerous small streams emptying into the Ohio River, and with ranges of hills between these streams of nearly uniform height and heavily wooded either with large timber or covered with a second growth of small trees and bushes. These are so thickly crowded together as to be very difficult to penetrate, and are not high enough to afford a view of the country from their tops.

Much time was necessarily spent in searching for stations that could be made intervisible, and, as the roads were few and very rough, travel in wagon or on horseback was slow, and almost all detailed examinations were made on foot. Flags in trees at heights of from thirty-five to one hundred and twenty-five feet above ground marked the stations as selected. All angles were measured from the tops of these trees with an azimuth compass and pocket sextant, and relative heights were determined with the aneroid barometer.

A practicable scheme was finally developed for extending the triangulation in the shortest time and at the least expense possible from the starting line in West Virginia, through parts of Southeastern Ohio and Northeastern Kentucky, to a line, Scioto–Johnson. The station Scioto is near the town of Portsmouth, Scioto County, Ohio; station Johnson is about four miles west of Quincy, Lewis County, Kentucky.

Field operations closed December 16. Special mention is made by Assistant Mosman in his report of the zeal, activity, and good judgment shown by Extra Observer W. B. Fairfield in overcoming the many difficulties presented by the reconnaissance.

In May, 1883, Assistant Mosman took the field, in pursuance of instructions, to organize a party for the continuation of the triangulation in accordance with the scheme developed by his reconnaissance, and was so engaged at the close of the fiscal year. Subassistant J. F. Pratt was temporarily attached to his party.

SECTION IV.

NORTH CAROLINA, INCLUDING COAST, SOUNDS, SEAPORTS, AND RIVERS. (SKETCHES Nos. 1, 5, 6 AND 7.)

Lines of deep-sea soundings and temperatures off the Atlantic coast of the United States.—Full mention has already been made under the heading of Section II of the cruise of the steamer Blake in the summer of 1882, under the command of Commander J. R. Bartlett, U. S. N., Assistant Coast Survey. In addition to the lines of deep-sea soundings and temperatures run by the Blake, a line for temperatures only was run from the Bermudas to Cape Hatteras, the temperatures of the surface being taken every mile; temperatures at twenty-five fathoms depth every ten miles; at four hundred fathoms every thirty miles, and at eight hundred fathoms every sixty miles. When entering the current of the stream the deep serials were taken at half of these distances.

For statements of other deep-sea investigations made by the Blake, see Sections I, II, and VI.

Hydrographic surveys of Cape Fear River entrance and in Croatan and Pamplico Sounds.—Upon arriving in Hampton Roads in command of the Schooner Silliman, Lieut. F. A. Wilner, U. S. N., Assistant, Coast Survey, was directed to proceed to Smithville, N. C., and make a hydrographic survey of the bar at Cape Fear River entrance. In pursuance of this duty Lieutenant Wilner reached Smithville February 4, 1883. He remarks in his report that the shifting character of this bar is too well known to call for special mention; that the channels are well buoyed, so that the only dangers a stranger will have to contend with will be found in the very strong tidal currents, and in the presence of a most dangerous pile of rocks known as the "Stone Fence," situated off the point of Bald Head Shoal, and just at the edge of the channel. These rocks are awash at half-tide and entirely covered at high water, so that not even a ripple indicates their position. In approaching them from the northward or southward the soundings will not show their vicinity until too late to avoid them if coming with the tide.

Lieutenant Wilner expresses his acknowledgments for information received from Mr. Henry Bacon, assistant engineer in charge of the improvements at the entrance for the Engineer Bureau, and to Capts. J. H. and T. Harper for many courtesies extended during the course of his survey.

Leaving Smithville April 10, Lieutenant Wilner proceeded with the vessel and party to Pamplico Sound to make a resurvey of the main channel from the Croatan to the Roanoke Marshes light, and to complete certain unfinished portions of the survey of Pamplico Sound. He passed into Pamplico Sound through Ocracocke Inlet, finding that the buoys were much out of place, and that unless wind and tide were both favorable, six and one-half feet of water could hardly be carried through. The main channel through Croatan Sound was found to be but little changed, except at the southern end, where new islands have formed and old ones have disappeared. Representations were made to Lieutenant Wilner while at Elizabeth City, N. C., of a desire on the part of navigators of the waters of Croatan and Pamplico Sounds for a change in the location of Croatan lighthouse; the reasons for the desired change are stated clearly by Lieutenant Wilner, but without expressing himself as in favor of it.

The hydrographic surveys required were completed by the 18th of May, soon after which the Silliman sailed for New York. Three hydrographic sheets showing the results of the work have been registered in the archives. Statistics are as follows:

Miles run in sounding	769
Angles measured	10,772
Number of soundings	59,740

Ensigns Francis H. Sherman and Harry Phelps, U. S. N., aided in the survey.

SECTION V.

SOUTH CAROLINA AND GEORGIA, INCLUDING COAST, SEA-WATER CHANNELS, SOUNDS, HARBORS, AND RIVERS. (SKETCHES NOS. 1, 6, AND 7.)

Hydrographic survey in the vicinity of Cape Romain, S. C.—Between the end of February and the beginning of May, 1883, a hydrographic survey off the coast of South Carolina in the vicinity of Cape Romain was made by the party in charge of Lieut. J. T. Sullivan, U. S. N., Assistant Coast Survey, commanding the steamer Endeavor. The area sounded included the immediate approaches to that portion of the coast between Winyah Bay and Bull's Bay. A hydrographic sheet, scale 1-10,000, showing the results of the survey, has been deposited for registry in the archives. The statistics are:

Miles run in sounding	164
Angles measured	1,678
Number of soundings	17,204

Lieutenant Sullivan was aided by Ensigns W. H. Allen, E. N. Fisher, and J. P. Parker, U. S. N.

About the 10th of May the Endeavor proceeded to Philadelphia, and under Lieutenant Sullivan's direction was prepared for a season's work in Section II.

Occupation of the station at Savannah, Ga., for the determination of the longitude of Saint Augustine, Fla., by exchange of telegraphic signals.—In co-operation with the party sent out by the French Government for the observation of the Transit of Venus at Saint Augustine, Assistant C. S. Peirce was directed to determine the longitude of the Transit of Venus station. For this purpose he detached Mr. E. D. Preston of his party with letters to Colonel Perrier, Chief of the Geographical Service of the French army, who was in charge of the observing corps at Saint Augustine.

All arrangements having been completed for the longitude observations, the station at Savannah—the same as that of 1874—was occupied by Mr. Preston, and at the station at Saint Augustine the observations were made by Captain Desforges. The location of the Saint Augustine station was in the middle of the north rampart of Fort Marion, the same pier being used as for the meridian circle of the Transit of Venus party.

For the first series of exchanges, results for longitude were obtained on the nights of November

30, December 1, and December 3; the observers then changed places, and signals were again successfully exchanged on the nights of December 16, 17, and 18. These completed the number of determinations required.

Before leaving Saint Augustine, Mr. Preston, by direction of Assistant Peirce, made a set of observations with the two new invariable reversible pendulums which had been swung at Montreal, Albany, Hoboken, and Washington, D. C. For this purpose the station occupied was in the chapel of the fort. He also determined the geographical position of the new light-house on Anastasia Island, Saint Augustine Harbor, and the height above mean tide of the Transit of Venus and pendulum stations.

SECTION VI.

PENINSULA OF FLORIDA, FROM SAINT MARY'S RIVER, ON THE EAST COAST, TO ANCLOTE KEYS ON THE WEST COAST, INCLUDING THE COAST APPROACHES, REEFS, KEYS, SEAPORTS, AND RIVERS. (SKETCHES NOS. 1, 8, 9, 10, AND 11.)

Hydrographic resurvey of Saint John's River and Bar.—Under instructions dated in December, 1882, and January, 1883, Lieut. E. D. F. Heald, U. S. N., Assistant Coast Survey, having organized his party on board the schooner Eagre, proceeded to the Saint John's River, Florida, for the purpose of making a hydrographic resurvey of that river and the bar at its entrance. The necessary signals having been established, soundings were begun January 30, and though many delays occurred from bad weather and thick atmosphere occasioned by fires in the forest adjacent, Lieutenant Heald was able to report the completion of the resurvey April 24.

Three hydrographic sheets, on a scale of 1–10,000, showing the results of the work, have been registered in the archives. They show the river from the entrance to a point just south of Jacksonville. On the bar the least depth was found to be six and a half feet at mean low water, the mean rise and fall of the tide at the entrance being four feet and six-tenths. The statistics are:

Miles run in sounding	126
Angles measured	1,812
Number of soundings	10,784

Lieut. David Daniels, U. S. N., and Ensigns O. G. Dodge and Alfred Jeffries, U. S. N., were attached to the hydrographic party. Upon leaving the Saint John's River, Lieutenant Heald was directed to take the Eagre to New York and prepare for a season's work on the coast of Maine.

Determination of the longitude of the Transit of Venus station at Saint Augustine, Fla., by exchange of telegraphic signals with Savannah.—Full reference has already been made, under the head of Section V, to observations made by Mr. E. D. Preston, under the direction of Assistant Charles S. Peirce, at Saint Augustine and at Savannah, for the determination of the longitude of the French Transit of Venus station at Saint Augustine, in co-operation with Col. F. Perrier, Chief of the Geographical Service of France, who was in charge of the Transit of Venus party sent to Saint Augustine by the French Government.

Duplicates of the records and results of the observations, made by Mr. Preston and by Captain Desforges, with whom he was immediately associated, will be deposited in the archives of the Coast and Geodetic Survey.

Reconnaissance of the Saint John's River from Lake Monroe to Lake Washington.—The course of the Saint John's River from Jacksonville to Lake Monroe is shown upon the reconnaissance map published in 1878 and subsequently in another issue, with additions to 1881. In February, 1883, Assistant Eugene Ellicott was directed to extend this reconnaissance from Lake Monroe to Lake Washington, the rapid development of Southern Florida having created a demand for a chart of the river to the head of navigation.

Mr. Ellicott's survey was begun February 27. Some extracts from his report will be of interest:

"From Lake Monroe to Lake Harney the river is comparatively bold and deep, with an average width of two hundred and fifty feet. The least depth of water encountered in a single line of soundings between Monroe and Harney is six feet; the greatest, twenty-two feet. The least depth

occurs where the river enters Lake Monroe. At the time the soundings were made the river was within a foot or two of its lowest stage.

"Lake Jessup is a beautiful body of water, and promises to become of some importance because of the good land on its south and west shores. It is, however, difficult of approach, as the depth of water about its mouth is meager, indeed insufficient for steamers other than the smallest at a low stage of water.

"The shores of Lake Harney are bold, as bold shores go in southern waters, and sandy. The maximum depth is twelve feet, the soundings not varying from this figure for an area of one square mile in the middle of the lake. As the river is again approached my line of soundings showed a decrease to five feet. The bottom of Lake Harney is hard white sand.

"From Harney to Salt Lake Landing the river is exceedingly crooked, but the steamers at present engaged in the trade of Indian River experience no undue difficulty in making their trips. This landing is the point of shipment for the Titusville section of Indian River. The distance across is eight miles.

"Lake Poinsett is like other lakes on the river, excepting that the shores are shelving and marshy. A mile east of Poinsett is a small creek or lake where is situated the landing of that name. From this landing it is three miles across to the west shore of Indian River. There is a scattering settlement (with post-office) known as Rock Ledge.

"From Lake Poinsett, up river, the difficulties attending navigation constantly diminish. The stretch of river between Lakes Poinsett and Winder is much better than in many parts near Jacksonville. The width is about four hundred feet; depth of water, eighteen to twenty-two feet, the banks bold, and the directions remarkably straight.

"The bar which must be crossed in entering the river above Lake Winder has (according to a single line of soundings) six feet of water, and I am inclined to think that a closer survey would show eight or nine feet.

"From this point up river, or to the southward, the conditions remain favorable to navigation, ample width of river and depth of water till the 'floating islands' are encountered, four or five miles above Lake Winder.

"These 'islands,' as they are called by the river men, consist of a dense vegetable mat, of a foot in depth, floating on the surface of the water, the decomposed vegetable matter having so welded the float together as to have admitted the growth of small willows four to six feet in height."

In the small steamer which had been hired for the survey, Assistant Ellicott succeeded in cutting through a float of 300 or 400 meters, and entering clear water, which only lasted half a mile, when another float appeared. The outlines of the northern shore of Lake Washington came in sight about three miles beyond, and here the work was closed.

Mr. Ellicott's report gives detailed statements showing the great and steady increase in the means of inland communication and in the trade and travel in the interior of Eastern Florida. Arrangements will be made for the early publication of his reconnaissance map.

Other surveys executed by Assistant Ellicott are referred to under the heads of Sections I and III.

Survey of the eastern coast of Florida from Indian River Inlet southward.—In accordance with instructions issued towards the close of November, 1882, Assistant B. A. Colonna proceeded to the east coast of Florida, and organized his party for executing the triangulation, beach-measurement, topography and hydrography of the east coast of Florida included between the limits of latitude 27° 25′ and 26° 13′ north.

The triangulation, in connection with the beach-measurement, was begun by Mr. Colonna from the limits of Assistant Boyd's work of the previous season near Indian River Inlet, and carried by him to the southward as far as Jupiter light-house, about thirty-five miles. Thence from Jupiter light-house it was carried fifty miles southward to Junction Station by Mr. W. B. Fairfield, extra observer, under Mr. Colonna's direction.

The topography was taken up near Indian River Inlet, and extended to the southward to about eight miles south of Jupiter light-house, including the shores of Saint Lucie and Jupiter Rivers, and covering three topographical sheets on a scale of 1–20,000. This work was executed by Mr. E. L. Taney, Aid in the party.

Later in the season the topography in the vicinity of Lake Worth was taken up by Mr. T. P. Borden, Aid in the party. This sheet had been partly completed when field operations closed.

The beach-measurement was committed to the care of Mr. Borden, who carried it from Ten Station (latitude 27° 05′), to Junction triangulation station, a distance of about sixty-two miles. Mr. W. B. Fairfield aided Mr. Borden in this measurement.

Assistant Colonna measured an azimuth at Ten Station, Jupiter light being used as an azimuth mark. Two magnetic stations were established, one at Refuge Station, and one at Bell Station; at these points were determined the magnetic declination, dip, and relative total intensity, the latter by Lloyd's method.

Early in May the hydrographic work was taken up. It covers the waters from Indian River Inlet to South Jupiter Narrows, including Saint Lucie River and Peck's Lake. The results are shown upon two full hydrographic sheets, and part of a third sheet, scale 1–20,000. About one-half of the hydrography was executed by Mr. Colonna personally; the remainder by Mr. W. B. Fairfield.

Field operations closed early in June. In his report Assistant Colonna expresses his hearty appreciation of the earnest and efficient manner in which all work entrusted to his Aids, Messrs. Borden, Taney, and W. B. Fairfield was executed. During part of the season, and until his detachment April 30, Ensign Edward Simpson, U. S. N., rendered valuable service. The statistics of the season's work are:

Stations occupied for azimuth	1
Stations occupied for magnetic determinations	2
Stations occupied in triangulation	31
Pointings with theodolite	12,228
Miles of beach-measurement with wire	62
Geographical positions determined	53
Miles of shore-line of rivers, ponds, &c	342
Area of topography in square miles	70
Tidal stations and bench-marks established	6
Miles run in sounding	451
Number of soundings	24,274

Duty in which Assistant Colonna was occupied at the beginning of the fiscal year is referred to under the head of Section XVII.

Survey of the shores and lagoons of East Florida from Key Biscayne northward.—The survey referred to in the preceding paragraphs, under the direction of Assistant B. A. Colonna, and carried southward along the coast of East Florida, met at Junction Station (latitude 26° 13′ north) a survey of a similar character carried from Key Biscayne Bay to the northward by the party in charge of Assistant O. H. Tittmann.

The schooner Ready, with Mr. Tittmann and party on board, arrived at Key Biscayne Bay early in February, and a search for the stations of the triangulation of 1849–'50 in that vicinity was at once begun. The North Monument established in 1855 to mark one of the ends of the primary base-line measured in that year was found undisturbed; the South Monument had been washed away, and was found lying on the bottom in several feet of water. Stations "Key Biscayne" and "Shoal Point" were recovered; the latter, with the old light-house tower on Cape Florida, furnished a base-line for the triangulation required to connect the old work with the proposed beach-measurement. This tower, ninety feet high, overtopped the tall mangrove growth on Key Biscayne, and thus served admirably the purpose of a central station for the triangulation.

In order to establish points on the beach for hydrographic purposes, it was deemed advisable to begin the beach-measurement at "Norris Cut" in latitude 25° 45′ (nearly). This line of measurement followed generally the high-water mark, and its direction was preserved by aligning with a four-inch universal instrument, which was carried from bench to bench, and plumbed over each one successively. At the same time the difference of elevation between the benches was determined by means of this instrument. The beach-measurement was begun February 22, and completed April 4, at Junction Station, the distance between the two points being about thirty-two miles.

The orientation of the survey, depending on the azimuth of the line "Old Tower–Shoal Point,"

was preserved by means of angles measured between the principal signals established along the beach.

A tertiary triangulation for checking the distances measured on the beach was carried from station "Dumfounding," in latitude 25° 57′ north (nearly), to station "Lauderdale," near latitude 26° 06′ north. At "Lauderdale" an astronomical azimuth was determined by two nights' observations made with a six-inch Gambey upon Polaris, direct, and reflected in mercury.

The topographical survey extended from the head of Key Biscayne Bay to station Lauderdale, and was finished May 10. It includes the shore-line of New River and its bayous, as well as that of the head of Biscayne Bay, Dumfounding Bay, and the upper portions of Snake and Arch Creeks.

New River, between its inlet and "Lauderdale," was sounded out, and some additional soundings required off Miami were made. Field operations were closed May 15.

Subassistant John B. Weir, Ensign E. M. Katz, U. S. N., and Midshipmen John A. Dougherty and L. S. Van Duzer, U. S. N., were attached to the party.

Duty assigned to Assistant Tittmann earlier in the fiscal year is referred to under the heading of Section II.

Hydrographic survey between Jupiter Inlet and Key Biscayne.—A hydrographic survey of the east coast of Florida between Jupiter Inlet and Key Biscayne was completed in May, 1883, by Lieut. H. B. Mansfield, U. S. N., Assistant Coast Survey, commanding the steamer A. D. Bache. Lines were run normal to the coast about one mile apart, always as far as the fifteen-fathom, and with but few exceptions as far as the twenty-fathom curve, every tenth line being extended to the one-hundred-fathom curve.

From Jupiter Inlet to Hillsborough Lieutenant Mansfield found the shore very clean, the three-fathom curve about one-eighth of a mile from the beach slanting gradually up to the beach, except south of Lake North Cut, where a narrow ridge runs at the edge of the three-fathom curve about ten miles to the southward. From the three-fathom curve the water deepens rapidly until an average depth of eleven fathoms is attained; it then shoals up to a ridge with nothing less than eight or ten fathoms about a mile from shore, and then falls off almost at a cast to sixteen and then to twenty fathoms, &c.

Between Hillsborough and Key Biscayne it is not so clean; the inshore reef slanting at Hillsborough has usually from three to four fathoms inside, and shoals again in some places to but five or six feet, not unfrequently extending nearly three-fourths of a mile from shore.

Three hydrographic sheets on a scale of 1–40,000 embody the results of the survey, the statistics of which are:

Miles run in sounding	295
Angles measured	1,902
Number of soundings	8,136

Ensigns W. B. Caperton, H. M. Wetzel, J. M. Orchard, and C. S. McClain, U. S. N., aided in the work.

Upon the completion of the survey the Bache was taken to New York for refitting and repairs. Hydrographic work upon the west coast of Florida executed by Lieutenant Mansfield earlier in the season will be presently referred to under the heading of this section; duty previously performed by him is stated under the heading of Section II.

Observations of currents at stations off Jupiter Inlet, Fla.—The instructions issued in February, 1883, in relation to observations of currents off the eastern coast of the United States by Master J. C. Fremont, jr., U. S. N., commanding the schooner Drift, have already been referred to under the heading of Section III. Having occupied four current stations at points between Cape Henry and Cape Fear, Master Fremont established his fifth station May 8, 1883, in the Gulf Stream off Jupiter Inlet, anchoring in one hundred fathoms, favorable conditions of observation prevailing, a smooth sea and a light wind. This station was occupied twenty-six and one-half hours. The sixth station was also in the Stream off Jupiter Inlet; depth, two hundred fathoms; time of occupation, twenty-four hours; date, May 10. The seventh station, in the axis of the Stream at a depth of about four hundred fathoms, was occupied during thirty-one and one-half hours; after completing

the observations at this station, the loss of an anchor through the giving way of the windlass mad it advisable to return with the Drift to Fernandina. At this port orders reached Master Fremor on the 18th of May directing him to take the vessel to New York, where she was prepared fo service in a cruise for observations of currents between Montauk Point and Cape May.

Deep-sea soundings, with serial temperatures, between the Bahamas and the Bermudas.—The dee sea sounding work executed by the hydrographic party on board of the steamer Blake, early in th fiscal year, has already been referred to under the headings of Sections II and IV. On the 9th December, 1882, the vessel left New York under command of Lieutenant Commander W. H. Brow son, U. S. N., Assistant Coast Survey. His instructions were to run a line of deep-sea sounding from the Bermuda Islands to the Bahamas, and then a series of normals to the northern face the Bahamas, far enough to develop the two-thousand-fathom curve.

The Blake anchored off Bermuda on the night of December 13, and after a delay of some da by bad weather, Lieutenant-Commander Brownson left Hamilton, and obtained his first soundin December 18, on Challenger Bank, depth twenty-eight fathoms. This was at 7 h. 50 m. p. m. Tw hours later a sounding gave bottom at four hundred and sixty-nine fathoms, and at 7 h. 20 m. ne morning a sounding was obtained in two thousand six hundred and thirty-two fathoms. Wit some delays, occasioned by loss of wire and thermometers, the line was completed to the Bahama surface, serial, and bottom temperatures being obtained in connection with the soundings whenev practicable. On this line the greatest depth sounded was three thousand and seven fathoms; th lowest temperature of bottom observed was 35½° Fahr.

Soundings were subsequently obtained on lines from Mariguana to Ocean Plateau; then down through Turk's Island to the coast of Hayti. Another line was run from Samana Promo tory to Navidad Bank, and thence out to Ocean Plateau.

Upon his arrival at St. Thomas, Lieutenant-Commander Brownson inferred from an inspectio of the chart to the northward of Porto Rico, in connection with the results which he had obtaine on the last line run and from the soundings of the Challenger, that very deep water would exten to the westward. His inference was soon after verified. On the 27th of January, in latitud 19° 40′ 50″ north, longitude 66° 23′ 40″ west of Greenwich, seventy-one miles west of the Challe ger's greatest depth, he sounded in four thousand five hundred and sixty-one fathoms, finding th bottom to be brown ooze and the temperature 36¼° Fahr. This is believed to be the greatest dept from which bottom specimens and temperature have been obtained.

Fifteen and a half miles southeast of the latter station another sounding was taken in fo thousand two hundred and twenty-three fathoms, the specimen brought up being of ooze in tw layers, brown on top with an under strata of gray. Temperature at bottom was 36° Fahr.

Lieutenant-Commander Brownson remarks in his report:

"The lines of soundings normal to the general direction of the Bahamas show the remarkab manner in which these islands rise up from the Ocean Plateau. With the exception of the line o Spanish Cay, Little Bahamas, in no case was the two thousand-fathom curve more than fourte miles from the nearest land, and in one instance we found one thousand nine hundred and sevent six fathoms only two and one-half miles from land. This would give a declivity of 38°. Referri to the deep sounding four thousand five hundred and sixty-one fathoms taken north of Porto Ri it is probable that deeper water can be found north and east of it, and I trust it may soon investigated."

From the data furnished by this and previous cruises of the Blake was constructed a model the western part of the North Atlantic Basin. The statistics of the work are:

Number of soundings with wire	151
Serial temperature stations occupied	27
Water temperatures observed, surface	141
Water temperatures observed, intermediate	174
Water temperatures observed, bottom	126

The following-named officers were attached to the Blake: Lieut. G. W. Mentz, U. S. N.; Ma ters Henry Morrill and Lucian Flynne, U. S. N.; Ensigns H. C. Wakenshaw, W. M. Constant, a

H. S. Knapp, U. S. N. The commanding officer expresses his appreciation of the great interest taken in the work by all the officers.

Arriving in New York early in February, Lieutenant-Commander Brownson received instructions to prepare the steamer for deep-sea sounding work and off-shore hydrography in the approaches to New York and in the vicinity of Nantucket Shoals.

Topographic and hydrographic survey of the west coast of Florida between Charlotte Harbor and Tampa Bay.—Having organized his party on board the schooner Quick at Manatee, Florida, early in December, 1882, Subassistant Joseph Hergesheimer proceeded to execute instructions directing him to make a topographic and hydrographic survey of the west coast of Florida between Tampa Bay and Charlotte Harbor.

The topographic survey was begun at Hunter's Point, Sarasota Bay, on January 1, 1883, and completed to Bocilla Pass at the entrance of Lemon Bay, on the 4th of June. During this period the weather was favorable for the work, the season being remarkable for an almost entire absence of the heavy northers which are usually of frequent occurrence during the winter. The inside hydrography also was finished by June 1; it included the hydrography of Sarasota and Little Sarasota Bays, Dona Bay, and Roberts Bay, and that of the bar and harbor of Stump Pass. That of Lemon Bay was postponed, owing to the lateness of the season.

Tidal observations were recorded at seven stations which were connected with each other and with the bench-mark established at Egmont light in 1873. Statistics of the season's work are as follows:

Miles of shore-line surveyed	368
Miles of roads	45
Area of topography in square miles	58
Miles run in sounding	564
Angles measured	3,903
Number of soundings	52,302

Mr. J. B. Boutelle, extra observer, rendered efficient service in the party.

Hydrography off the west coast of Florida to the northward and southward of Tampa Bay.—In pursuance of instructions issued to Lieut. A. B. Mansfield, U. S. N., Assistant Coast Survey, he proceeded with his party on board of that vessel to the west coast of Florida, to continue the hydrography off that coast, northward and southward of Tampa Bay.

Arriving in Tampa Bay January 17, 1883, he established a tide-gauge at Egmont Key and began soundings. One double hydrographic sheet, scale 1–40,000, showing the hydrography between Blind Pass and Big Pass was finished February 17. With reference to the characteristics of this part of the coast, Lieutenant Mansfield remarks:

"The bottom is irregular and in ridges to five or six fathoms, and then deepens gradually. The shore is low, and the hills back of the beach are usually, in clear weather, just seen from the ten-fathom curve. In running this work to the limits of the five-fathom curve, the currents were found to be tidal. Outside the prevailing current, was found a slight one from the southward along the coast. In calms this current had a rate of about three-tenths of a knot, increasing to six-tenths in a fresh breeze from south around to west. It would be checked after northerly winds, and in a few cases, after a heavy norther, it had a slight set to the southward."

After a trip to Key West for coal and stores, work was taken up on that part of the coast between Bocilla Pass and New Pass, March 2. Within half a mile of the shore, the water was found to deepen to four or five fathoms, except off the passes. Beyond that depth the deepening was gradual, as on the upper sheet. The same current effect was noted. The hydrographic sheet, a double one, scale 1–40,000, was finished April 10. Previous to this date, some soundings had been made in the west channel of the Manatee River; these are shown upon a separate sheet, scale 1–10,000.

For the work upon the west coast of Florida, the statistics of the season are:

Miles run in sounding	1,022
Angles measured	2,411
Number of soundings	22,928

Ensigns W. B. Caperton, H. M. Wetzel, J. M. Orchard, and C. S. McClain, U. S. N., we attached to the hydrographic party on board the Bache. Work upon the east coast of Florid executed by Lieutenant Mansfield and party after the completion of the west coast work, h already been referred to under the heading of this section.

SECTION VIII.

ALABAMA, MISSISSIPPI, LOUISIANA, AND ARKANSAS, INCLUDING GULF COAST, PORTS, AND RIVERS.

(SKETCHES NOS. 1, 6, 13, 14, AND 24.)

Reconnaissance for the connection of the Gulf coast triangulation on Mobile Bay, Ala., and vicini with the primary triangulation at or near Atlanta, Ga.—Having been charged with making a reco naissance for a triangulation between the Gulf of Mexico at or near Mobile Bay, and the prima triangulation near Atlanta, Ga., Assistant S. C. McCorkle proceeded to Mobile, Ala., in Januar 1883, and began a careful search to ascertain what points of the old triangulation could be foun with which to connect the scheme of reconnaissance.

For transportation, which greatly facilitated his labors, Mr. McCorkle acknowledges his indeb edness to Capt. A. N. Damrell, United States Engineers, and to Capt. T. W. Lay, United Stat Revenue Marine.

In the explorations for the old triangulation marks on and near Mobile Bay, great changes shore-line and other topographical features were found. The coast has been visited by gales great severity since the former survey, and the shores of the bay, especially at the points and bluf where stations were generally established, have been washed away from thirty to sixty feet. Up Dauphin Island, where search was made for the monuments marking the ends of the primary bas line measured in 1847, the granite blocks at East Base were found, but were lying on their sid apart from each other and entirely out of position. Search was made unsuccessfully for the unde ground marks. The blocks which had marked the West Base could not be found. Nearly tw thirds of the island on the south side has been entirely submerged, and the south shore has bee very largely washed away, while the north shore-line seems to have been greatly extended. Pelica Island has entirely disappeared.

Having identified five points of the former triangulation, one of which was the station at Fo Morgan, Assistant McCorkle began his reconnaissance of the country between Mobile and Atlant This duty occupied him during the months of March and April. His report gives full details i regard to the features of the country, with statements of the location, general direction, and elev tion of the ridges, and concludes by recommending the adoption of either Kenesaw–Carnes Carnes–Indian Mountain, lines of the primary triangulation between the Maryland and Georg base-lines, as bases for the triangulation between Atlanta and the Gulf of Mexico.

Mr. W. O. Jones served as acting Aid in the party. In the earlier part of the fiscal ye Assistant McCorkle was engaged in duty which is referred to under the heading of Section II.

Continuation of the survey of the coast of Louisiana, west of the Mississippi River.—A topograph and hydrographic survey of the south coast of Louisiana, from Barataria Bay eastward towar the Mississippi Passes, was carried on by Assistant C. H. Boyd during February, March, and part April, 1883. Having organized his party on board the steamer Barataria, Mr. Boyd arrived i Barataria Bay February 7, and began work by a search for stations of the triangulation of 187 which might serve as a base of operations. Having recovered "N. E. Base" and "Grand Terre," triangulation solely for the determination of topographic and hydrographic points was carried fro this line as a base as far as Sandy Point, near the present mouths of the "jump." As soon points enough could be determined, the shore-line survey was begun at Ronquille Bay, and followe the triangulation on the outer islands, and the bays and bayous adjacent thereto, covering groun enough to develop the characteristics of the Gulf shore as far as Skofield's Bayou.

Soundings were made in the bayous and shoal-water bays inclosed by the topographical sheet Tidal records were kept near each anchorage of the steamer during the time that this work w in progress.

Field-work was closed in accordance with instructions April 24, and the steamer laid up at New Orleans.

Midshipman James C. Drake, U. S. N., rendered acceptable service in the party; Mr. J. De Wolf, extra observer, served efficiently in topographical duty.

Scale of execution of topography and hydrography, 1–30,000. Statistics are as follows:

Shore-line surveyed, miles	160
Area of topography, square miles	50
Lines run in sounding, miles	70
Number of soundings	5,000

Duty in which Assistant Boyd was engaged earlier in the fiscal year is referred to under the heading of Section I.

Survey of the coast of Louisiana from Sabine Pass eastward.—Under the direction of Assistant F. Walley Perkins, and in pursuance of instructions issued in November, 1882, a party was organized for the extension of the survey of the coast of Louisiana from Sabine Pass to Calcasieu Pass.

Mr. Perkins organized his party and began preliminary arrangements for the work in December, but actual operations were delayed for a time by heavy rains, producing an overflow of the country and rendering the marshes almost impassable. As soon as the weather would admit, the survey was pushed vigorously in its several branches. About the middle of January the stations in the vicinity of Sabine Pass were occupied to begin the triangulation by Mr. G. F. Bird, Aid in the party. The topographical survey was commenced near the Pass at the same time by Sub-assistant W. C. Hodgkins.

During parts of February and March a base-line of verification was twice measured; the two measurements were found to be in close accord.

The latitude of West Base Station was determined with the meridian telescope, and the azimuth of the base-line was established by observations upon α Urs. Min., 51 Cephei, and δ Urs. Min. This work, with the continuation of the triangulation and topography towards Calcasieu light, and a hydrographic survey of a portion of Calcasieu Pass, occupied the party until near the end of May, when field operations were closed.

Assistant Perkins' report contains suggestions derived from his experience in the field as to the best methods of prosecuting the survey on this part of the coast. He presents the following statistics of work accomplished:

Length of base-line measured in meters	4,134.1
Number of pairs of stars observed for latitude	26
Number of observations for latitude	83
Number of pointings on stars for azimuth	132
Number of stars observed for time	100
Geographical positions determined	34
Directions determined	153
Number of pointings made in triangulation	6,822
Total number of miles of shore-line delineated	582
Miles of railroad	9
Miles of roads	41
Area surveyed in square miles	200

The scale of the three sheets, showing results of the topographic survey, is 1–20,000.

In the hydrographic work, Assistant Perkins had the aid of Lieut. Lucian Flynne, U. S. N., who reported for duty, with the steamer Hitchcock, about the end of March.

The statistics presented bear witness to the energy displayed by the party of Assistant Perkins in the conduct of the survey. Work executed by him earlier in the fiscal year is referred to under the heading of Section XVI.

Determination of the longitude of Little Rock, Ark., by exchange of telegraphic signals with Saint Louis, Mo.—In November, 1882, a determination of the longitude of Little Rock, Ark., was made by exchanges of telegraphic signals with Saint Louis, Mo. The station at Saint Louis was occupied during the summer and autumn of 1882 by the party of Assistant G. W. Dean for the exchange of

longitude signals with a number of stations in the interior States. At Saint Louis the observatio
were made by Carlisle Terry, jr., Aid in the Survey, attached to Mr. Dean's party; at Little Ro
Subassistant F. H. Parsons established the longitude station and made the observations.

Little Rock being one of the secondary stations in the scheme of operations, the observers d
not change places. Very satisfactory results were obtained by the three nights' exchanges, Nove
ber 6, 7, and 10.

The latitude of the station was determined by eighty-one observations upon fifteen pairs
stars. Reference is made to other stations occupied by Mr. Parsons under the headings of Sectio
XIII and XIV.

SECTION IX.

TEXAS AND INDIAN TERRITORY, INCLUDING GULF COAST, BAYS, AND RIVERS. (SKETCHES NOS. 1 AND 1

Hydrography of the coast of Texas, from Galveston entrance, eastward.—Lieut. E. M. Hugh
U. S. N., Assistant Coast Survey, having assumed command of the steamer Gedney, in pursuan
of instructions issued in December, 1882, proceeded to Galveston, Tex., and organized his par
on board that vessel for the extension of the hydrography of the coast of Texas from Galvest
entrance to the limits of the completed triangulation.

On the passage from New York the steamer encountered very bad weather and sustain
damages which compelled her commander to put into Smithville for shelter, and to have her dock
at New Orleans for repairs. It was therefore not until February 14 that field-work could be begu

The work executed between this date and the close of the season, April 30, comprised a surv
of Galveston inner bar, the erection of signals along the beach for a distance of forty miles ea
ward of Galveston, and the completion of off-shore soundings, to include the ten-fathom curve,
a point thirty miles to the eastward of Galveston entrance. This leaves twenty-five miles
hydrographic work yet to be done to complete the hydrography to Sabine Pass.

Lieutenant Hughes has submitted a comprehensive report of his survey, complete as regar
all details of its execution, and stating the leading features and peculiarities of the coast. So
extracts from this report are here given:

"The coast eastward from Galveston being extremely low, large signals were necessary, a
these were built in the most substantial manner to withstand the northers and the southeast gal
prevailing during the winter months. For the first twenty-five miles from Galveston no sign
were found, but the points were recovered with no trouble whatever, owing to the fact of each o
being marked by a bushel or two of white shells on the surface. The signals erected are fr
forty to sixty feet in height, and will undoubtedly be found standing during the coming winter.

"During the past season the weather was extremely unpropitious, February being foggy a
March and April stormy, with much haze and fog. In almost every instance, where the sea w
smooth enough for working, the weather was so thick that signals could not be seen two miles
shore. Nearly all the work accomplished was achieved only by going out on the back of a nortl
and putting in every available moment, for as the northerly wind died out it invariably haul
around to the eastward, and within forty-eight hours blew up heavily from southeast.

"No regular current stations were made, but the current was measured on anchoring, bef
getting under way, and, at times, at the end of a line off shore. On the shoal area, extending w
off the coast near Galveston, the current is largely controlled by the wind in direction, and
strength is variable, in so marked a degree that the result obtained in one place is of not the le
value in forecasting that at another five miles further out or in. The maximum current encounte
was on April 18, steaming to the westward for Galveston, about four miles off shore. For a peri
of 6.2 hours we stemmed a mean current of 1.6 knots per hour, setting ENE. (Wind SSW. 4–6

The results of the survey are shown upon two hydrographic sheets upon scales of 1–80,000
the coast approaches and 1–10,000 for the inner bar of Galveston. Statistics are as follows:

Miles run in sounding	**714**
Angles measured	**1,026**
Number of soundings	**10,276**
Number of specimens of bottom preserved	**39**

Lieut. C. McR. Winslow, U. S. N., and Ensigns T. M. Brumby, W. C. Canfield, and William Truxtun, U. S. N., were attached to the hydrographic party under the direction of Lieutenant Hughes. After the close of the season, the Gedney proceeded to New York, where she was prepared for service on Long Island Sound. Duty performed by Lieutenant Hughes earlier in the fiscal year is referred to under the heading of Section II.

Topography of the shores of Nueces Bay; triangulation in the vicinity of Matagorda Bay; measurement of a base of verification and observations for azimuth.—With a view of resuming work upon the coast of Texas at the earliest date that the abatement of the yellow-fever epidemic on that coast rendered desirable, Assistant R. E. Halter proceeded to San Antonio, Tex., and thence to Corpus Christi, in the autumn of 1882, in pursuance of instructions directing him to complete the survey of Corpus Christi Bay. He took up work on the shores of Nueces Bay (the upper part of Corpus Christi Bay) late in October, and finished the topography needed, early in January, 1883. He was then directed to organize his party at Matagorda, Tex., for the verification of the old triangulation between the head of Matagorda Bay and the terminal points of the primary triangulation from Galveston Island southwestward. For this purpose he first made search for two or more points of the triangulations of 1853 and 1855, and connected them by a new triangulation, depending upon a new base, the site of which was selected by him on Matagorda Peninsula and its length measured. All of the old station points immediately on the coast of the Gulf had been washed away or destroyed, but on the mainland the old lines, Seven Mile–Live Oak and Prairie–Kenner, were re-established, connected with the new base, and the direction of the base-line determined by observations of azimuth.

Later in the season search was made for stations of the triangulation of 1851 between Cany Bayou and West Base, Galveston Island, but without other success than that of finding two points, "Cottonwood" and "Oyster Creek," both on the side of the main land. Field operations were closed early in June, and arrangements made to continue the work in the following autumn.

Assistant Halter has submitted the following statistics of the season:

Shore-line surveyed, miles	43
Roads, length of, in miles	17
Area of topography, in square miles	5
Number of observations in triangulation	1,610
Number of observations for time	366
Number of observations on star and on mark for azimuth	174
Length of base-line, in meters	3,786

Mr. J. E. McGrath served as Aid in the party.

SECTION X.

CALIFORNIA, INCLUDING THE COAST, BAYS, HARBORS, AND RIVERS. (SKETCHES NOS. 2, 15, 16, 17, AND 24.)

Establishment of a magnetic self-registering-record station at Los Angeles, Cal.—Reference was made in my last annual report to the site selected for a permanent magnetic station for observations to be made in co-operation with the work of the Signal Office and with that of the International Polar Commission. In pursuance of instructions issued in July, 1882, Mr. Werner Suess, of the Coast and Geodetic Survey, proceeded to Los Angeles, Cal., and took temporary charge of the magnetic observatory, which had been erected by Assistant James S. Lawson in the grounds of the State Normal School.

Immediately upon his arrival Mr. Suess began preparations for placing the self-registering record instruments (the Adie magnetographs) in position and adjustment. The main pillars for the clock, the declinometer, the horizontal and vertical force magnets having been set before the erection of the building, it remained only to place the pillars for the lamps and reading telescopes. For this purpose Mr. Suess mounted the instruments temporarily, and by the close of July had secured the slate and marble bases on their respective columns. The final adjustments were made with the co-operation of Mr. Marcus Baker, Acting Assistant, who arrived in Los Angeles early in

August to take charge of the observatory. By the 28th of September, the sensitive photograph paper was in place upon the cylinders in readiness for the adjustments of the driving clock, of ill mination, and for testing the chemical processes. In October the actual registry with the magne ograph began, and a continuous record of the magnetic elements was obtained photographically.

Determinations of the absolute values of the magnetic declination, dip, and intensity we made in September on the usual term days, and were continued monthly. For this purpose temporary building was put up at some distance from the one containing the differential instr ments.

The changes of magnetic declination, changes of horizontal force, and changes of vertical for recorded by the magnetographs on separate sheets have been developed successfully during ea month up to the date at which this report closes. The tabulations have also been made and t means calculated.

A thermograph record, on which the temperature of the magnet room is recorded automaticall every half-hour, has been kept continuously since November, 1882. Time observations for the reg lation of the standard chronometer have been taken regularly each month.

Following is a summary of the various observations, from the date of beginning in Septembe 1882, to June 30, 1883:

Number of observations for time	328
Number of observations for azimuth	98
Number of angles observed	14
Number of temperature observations	2,270
Number of observations for magnetic constants	826
Number of observations for absolute declination	1,028
Number of observations for absolute dip	3,270
Number of observations for absolute intensity	1,330
Number of unifilar observations	6,520
Number of bifilar observations	6,418
Number of vertical-force observations	6,450

Since January, 1883, Mr. Lucius Baker has aided in the routine work of the observatory.

Continuation of the primary triangulation northward from Point Concepcion.—Assistant Jam S. Lawson, upon his return in August, 1882, from Los Angeles, Cal., where he had superintend the building of a magnetic observatory, was assigned to the charge of the primary triangulati northward of Point Concepcion. The scheme, as laid out, involved the occupation of a series primary points, connecting with "Santa Lucia," one of the southern stations of Assistant Davi son's work, and starting from the line "Lospe–Tepusquet."

Having posted heliotropers at the stations to be observed upon, Assistant Lawson occupi "Tepusquet." Progress was much delayed at this station by the thick and smoky condition the atmosphere, and by a prevalence of strong east and northeast winds bringing dense clouds dust from the Great Valley of California. In many instances these dust storms would so envel the country that in a few hours even the tops of the nearest ridges, half to three-quarters of a mi distant, were barely visible. Much injury was done to the camp by the violence of the winds, tv tents and the flies of others being blown to pieces.

While at Tepusquet, Assistant Lawson was directed to report temporarily to Assistant Geor Davidson for duty in the party organized by him for the observation of the Transit of Venus at station in New Mexico. Leaving his party in charge of his aid, Mr. P. A. Welker, in Novemb 1882, Mr. Lawson, upon his return in January, 1883, found that the work at Tepusquet had be completed and that the occupation of Lospe had just been begun. At this station a succession fogs, quite unusual for the season, was experienced, the greater number of days in March and Ap being foggy.

All of the observations needed at Lospe were obtained by the 26th of May, when field oper tions closed. Mr. Lawson and his aid returned to San Francisco, and, in accordance with instru tions, they reported to Assistant George Davidson for duty under his direction.

The statistics of the work accomplished at the two primary stations are as follows:

Number of pointings for horizontal direction	1,384
Number of pointings for vertical angles (double zenith distances)	1,536
Number of nights on which stars were observed for azimuth	13
Number of stars observed for time	35
Number of observations for time	298
Number of pairs of stars observed for latitude	45

Not included in the above summary are the numerous sets of observations taken for the determination of instrumental constants.

At Tepusquet the third and fourth contacts of the Transit of Venus, December 6, 1882, were observed by Mr. Welker. For details, see Appendix No. 16.

Near Lospe Station was found Substitute Station of the tertiary triangulation of Assistant Greenwell in 1878. This was connected with the primary triangulation both by measures of angles and of distances from Lospe by a steel tape.

Reference will be made under the heading of Section XVI to the work of Mr. Lawson as assistant astronomer in the party under the charge of Assistant George Davidson for the observation of the Transit of Venus at Cerro Roblero, N. Mex.

Hydrographic survey from Monterey southward.—In continuation of the hydrographic survey of the coast of California, Lieut. W. T. Swinburne, U. S. N., Assistant Coast Survey, commanding the steamer McArthur, proceeded with his party on board that vessel to Monterey, Cal., early in January, 1883, in accordance with instructions issued during the previous month.

Having located his tidal station and begun a set of observations to obtain a plane of reference for his soundings, Lieutenant Swinburne took advantage of the favorable weather which prevailed generally during the season and completed the hydrography from Point Pinos to Cooper's Point between the 5th of January and the 16th of May. This tidal station was referred to the Coast Survey bench-mark established near Monterey in 1854.

The results of the survey are shown upon five hydrographic sheets—each upon a scale of 1–10,000. The statistics are:

Miles run in sounding	652
Angles observed	2,722
Number of soundings	11,510

The depths sounded ranged from one foot to five hundred and forty fathoms.

The following-named officers were attached to the hydrographic party on board of the McArthur: Lieuts. J. B. Milton and W. P. Elliott, U. S. N.; Master F. H. Lefavor, U. S. N.; and Midshipman P. B. Bibb, U. S. N.

Duty assigned to Lieutenant Swinburne on the California coast in other portions of the fiscal year until his detachment from the Survey in May, 1883, will be referred to later, under the heading of this section.

Operations at San Francisco, Cal., for the determination of the longitude of the Transit of Venus Station near Fort Selden, N. M., by exchanges of telegraphic signals. Observations of the Transit at San Francisco.—After the completion of the observations of the Transit of Venus of December, 1882, at Cerro Roblero, near Fort Selden, New Mexico, under the direction of Assistant George Davidson, arrangements were made by Mr. Davidson for the determination of the longitude of his station by exchanges of telegraphic signals with San Francisco.

The station of observation on the summit of Cerro Roblero was referred by triangulation to a station at Fort Selden, and this latter station was connected by telegraph line with the astronomical station of the Coast and Geodetic Survey at Lafayette Park, San Francisco.

Assistants Davidson and Lawson made the observations for time at Fort Selden, using the Davidson meridian instrument No. 1. The charge of the work at the San Francisco station was assigned to Assistant J. J. Gilbert, with Mr. C. B. Hill as recorder. Time was determined with the Troughton and Simms transit No. 3. Clock signals were exchanged upon five successive nights, complete sets of time determinations being obtained before and after each exchange of signals. Assistants Davidson and Gilbert subsequently observed upon three nights for personal equation.

Assistant Davidson gives the following results for the longitudes of Fort Selden and the Transit of Venus Station from the field reductions:

Telegraphic longitude, Fort Selden Station, $7^h\ 07^m\ 40^s.56$ west of Greenwich.

Telegraphic longitude, Cerro Roblero, $7^h\ 07^m\ 41^s.24$ west of Greenwich.

At the Davidson Observatory in San Francisco, and elsewhere upon the Pacific coast, an unusually steady atmosphere prevailed upon the day of the Transit of Venus, and successful observations were made at the station just named by Assistant Gilbert, who had been assigned to the charge of the work.

Mr. Gilbert, aided by Mr. Ferdinand Westdahl, used the 6.4-inch equatorial in making measures of the polar and equatorial diameters of the planet on the sun's disk, the distance apart of the cusps, and the III and IV contacts. The other observers at this station, with other instruments, were Assistant E. F. Dickins, Mr. C. B. Hill, and Mrs. George Davidson.

At the Coast and Geodetic Station on Mount Diablo, Cal., observations of the Transit were made by Mr. Justin P. Moore, vice president of the California Academy of Sciences.

Detailed reports of the observations at the California stations are included in the full report of Assistant Davidson, which has been transmitted to the Superintendent and to the President of the Transit of Venus Commission.

Reference will be made later under the heading of this section to the occupation of Mount Tamalpais and to other duty in the field and in the office executed by the party of Assistant Davidson.

Completion of the supplementary survey of the San Francisco Peninsula.—As stated in my last annual report, the supplementary topographical survey of the San Francisco Peninsula, which had been committed to the charge of Assistant Louis A. Sengteller, was nearly completed at the beginning of the present fiscal year. A hydrographic examination of the city front of San Francisco and of Oakland Creek and its approaches was in progress at the end of June and was finished early in July, 1882. With this, it was deemed that all necessary work had been accomplished.

The hydrographic sheet was finished at the San Francisco suboffice by Mr. Ferdinand Westdahl, draughtsman, under Assistant Sengteller's direction, and transmitted to Washington about the middle of August.

Duty subsequently assigned to Assistant Sengteller will be referred to under the heading of Section XI.

Determinations of the force of gravity and of relative magnetic intensity at San Francisco, Cal., in connection with similar determinations to be made at Point Barrow, Alaska.—In furtherance of plans initiated during the preceding year, by virtue of which the Coast and Geodetic Survey co-operated with the Signal Service in establishing a station of the International Polar Commission at Point Barrow, Alaska, Mr. R. A. Marr, Acting Assistant, was directed in May, 1883, to proceed to San Francisco, Cal., and thence to Point Barrow with the Signal Service Relief Expedition, appointed to sail from the former port in June, 1883.

Before leaving San Francisco Mr. Marr was instructed to swing his pendulum (Peirce No. 4) at such station as should be selected by Assistant Davidson as a permanent pendulum station, and to vibrate the magnet of his magnetometer on several days with a view of determining the relative horizonal intensity between San Francisco and Point Barrow.

Six sets of oscillations were obtained for the gravity determinations at the pendulum station, corner of Clay and Octavia streets, a pier having been set up, and a small building constructed for that purpose. The magnet of magnetometer No. 6 was vibrated upon four successive days at the Presidio Magnetic Station.

On the 16th of June Mr. Marr left San Francisco on the schooner Leo for Ooglaamie, Point Barrow, Alaska.

Determinations of the force of gravity at San Francisco in connection with similar determinations at the Transit of Venus Station in New Zealand, and at stations in Australia and Eastern Asia.—Assistant Edwin Smith, who had been in charge of the party for the observation of the Transit of Venus at Auckland, New Zealand, and by whom had been made sets of observations with the Kater invariable pendulums at the Transit of Venus Station and at other stations in the east, arrived at San Francisco with his assistant, Prof. H. S. Prichett, on the 31st of May, 1883. He

brought with him the Kater pendulums, to be swung, in accordance with instructions, at the pendulum station selected by Assistant Davidson at the corner of Clay and Octavia streets, San Francisco. Having rendered some assistance to Mr. Marr, whose prospective work in Alaska has just been referred to, Mr. Smith swung the three Kater pendulums continuously from June 20 to June 26, observations for time being made on each night. Professor Prichett aided in the work until his detachment June 22, after which Mr. Smith had the aid of Assistant E. F. Dickins.

Further reference is made to the valuable comparative determinations of gravity obtained by means of these pendulums in Part I of this report, under the heading of "Special Scientific Work," and again towards the close of Part II, under the heading "Special Operations."

Tidal observations with self-registering tide-gauge continued at Saucelito, near San Francisco Bay entrance.—The self-registering tide-gauge at Saucelito, just inside of the entrance to the bay of San Francisco, has been run very successfully and without interruption by Mr. E. Gray. The work has been done under the direction of Assistant Davidson, who transferred the gauge and the datum plane in 1877 from the Fort Point Station, where tidal observations had been continued for about twenty-three years. This datum plane has been adopted as a plane of reference by the city of San Francisco, the State Board of Harbor Commissioners, and the railroad companies. Constant application is made for data from the observations.

The earthquake waves from the great Java earthquake were reported from this tidal station before any notice of earthquake or volcanic eruption had been made known.

Occupation of a station of the primary triangulation north of San Francisco Bay.—In continuation of the primary triangulation north of San Francisco Bay, and to complete the series of directions in the Davidson quadrilaterals coming from the Yolo Base Line, Assistant George Davidson had made arrangements, at the beginning of the fiscal year, for the occupation of Mount Tamalpais. As mentioned in my last annual report, the station was prepared for occupation by Subassistant Pratt, and upon Mr. Davidson's arrival, August 24, observations were begun.

The work included a full series of horizontal directions upon seven main stations and four primary and secondary stations. One of these was the dome of the Lick Observatory at Mount Hamilton; observations from Sierra Marina will determine its geographical position.

With reference to the weather experienced at Mount Tamalpais and the methods of observation, &c., some extracts from Assistant Davidson's report are given:

"The season was exceptionally unfavorable for triangulation, the worst I have met with for many years. The smoky atmosphere was persistent to four thousand or five thousand feet elevation; the winds at the height of our station were rarely strong, and the smoke was seldom cleared away. For days and days it was frequently impossible to see over five miles. I never saw the signal on Rocky Mound, distant only nineteen and one-half miles, and finally had to use a heliotrope there. The smallest heliotrope I used during the season was three inches square; six inches square failed to penetrate forty miles in what was the medium condition of the smoke. This smoke comes from the burning forests in the north and in the Sierra Nevada, and from the burning of the high grain stubble of the many valleys. The fogs below us were usually one thousand two hundred to one thousand six hundred feet deep, and when they rose higher they seemed to increase the trouble by creating a bright haze. When the fogs would clear from the valleys and variable winds blow, the heliotrope signals would appear as flames or boiling objects of thirty-five to fifty seconds diameter.

"The total number of observations upon the main stations is nine hundred and forty-two in twenty-three positions of the instrument, the plan involving two observations in each position; broken series necessarily increased the number on some stations. The number of ocular pointings was three thousand five hundred and fifty.

"For my initial direction I used Mount Diablo, thirty-eight miles distant, observing upon it in connection with the azimuth observations. In all of these observations I used the ocular micrometer readings; the heliotropes were frequently twenty, twenty-five, and thirty seconds in diameter, very irregular, and boiling or flaming without any nucleus; when smaller, jumping five to ten seconds each side of the cross hairs, or slowly moving five seconds, so slowly that I could not decide sometimes where the mean lay. Without using the ocular micrometer to correct the initial pointing I should frequently have been compelled to forego observing, and thus protract the work.

In its use I feel a certainty and confidence which have greatly impressed me with the value of the method, and the results confirm my judgment. Even when all the signals are showing, the method has never prevented me from making all the observations necessary at any morning or afternoon work."

For azimuth, observations were made upon B. A. C. 4165 at western elongation, and α Urs. Min. at eastern elongation, the position of the instrument being changed for each star. From Mount Tamalpais the light of the six-inch plano-convex azimuth lens at Mount Diablo (thirty-eight miles distant) was frequently visible to the naked eye, and was sometimes observed through moderate smoke. The ocular micrometer readings were used on the Mount Diablo light, but not on the star. At the close of each night's work the direction of the light on the S. E. Farallon was observed.

For azimuth two hundred and sixty-seven observations were made on the mark and three hundred and seventy-six on the stars. The number of ocular pointings was one thousand.

For time and latitude, the observations were made by Subassistant J. F. Pratt, with meridian instrument No. 1 and zenith telescope No. 1. For latitude, twenty-eight pairs of stars were observed on an average of seven nights, and for time, two hundred and forty-two observations were made on twenty-two nights. The usual observations for instrumental constants were made.

Subassistant E. F. Dickins was assigned to duty in Mr. Davidson's party on the 29th of July. He assisted in the preparations for field-work, examined several main triangulation stations and posted the heliotropers, set up the azimuth lens at Mount Diablo, and observed the vertical angles to all of the main stations. For this purpose four hundred and twenty-six double zenith distances were observed upon eight objects.

At this station Assistant Davidson and Subassistant Pratt observed upon the great comet of 1882, making meridian observations for right ascension and declination on three days, and subsequently a large number of observations for altitude and azimuth.

Mr. C. B. Hill kept the records of observation of horizontal directions and of azimuths, and aided Mr. Davidson and his assistants in the current work of the party. By the 9th of October, all observations needed at Mount Tamalpais were completed. It had been expected to occupy Sierra Marina as the next station in the series, but the delays caused by bad weather, and the necessity of beginning at once preparations for the organization of the party to observe the Transit of Venus at a station in New Mexico, made a postponement of that occupation unavoidable.

Full reference is made in Part I of this report, and under the heading of Section XVI in this part, to the observation of the Transit under the direction of Assistant Davidson.

After his return from that duty early in 1883 to the close of the fiscal year he was occupied in the preparation of his report upon the observation of the Transit, in the completion of his "Field Catalogue of 1278 Time and Circumpolar Stars," and in the compilation of material for a new edition (the fourth) of the Coast Pilot of California, Oregon, and Washington Territory. The great amount of new material available since the publication of the edition of 1869 has made it necessary to rewrite this Directory, and the usual office duties have retarded its speedy completion. The first part, comprising the coast from San Diego to San Francisco, will be put in print whilst the second part is in preparation.

In answering calls for information upon the suboffice at San Francisco, Assistant Davidson had the aid of Messrs. Ferdinand Westdahl and C. B. Hill; the former aided also in Coast Pilot work, and the latter in general office-work and at the observatory.

During the year, assistance was rendered by Assistant Davidson to the parties of Assistant Smith and of Mr. Preston and Mr. Marr in making their pendulum experiments at the Lafayette Park station, where a temporary building had been erected for this work and for comparing base-bars.

Continuation of the hydrographic survey in the vicinity of Point Arena, Cal.—Early in July, 1882, Lieut. W. T. Swinburne, U. S. N., Assistant Coast Survey, was instructed to make ready for sea the steamer McArthur under his command, and to proceed to the vicinity of Point Arena, Cal., in order to make a hydrographic survey in continuation of that made by his party during the preceding season. To this survey between Bodega Bay and Point Arena, reference was made in my last annual report.

The hydrography executed between October 5 and November 23, 1882, extends from Point Arena to Salmon Point, and is comprised in three sheets on a scale of 1–10,000, ranging in latitude from 38° 55′ to 39° 13′ north, and in longitude from 123° 40′ to 123° 49′ west of Greenwich. Statistics of the work are:

Miles run in sounding	312
Angles measured	1,170
Number of soundings	6,458

In this work Lieutenant Swinburne had the aid of Lieuts. J. B. Milton and W. P. Elliott, U. S. N., and of Master F. H. Lefavor, U. S. N.

Other service performed in the McArthur by Lieutenant Swinburne and by his successor in command, Lieut. E. D. Taussig, is reported under the heading of this section.

Hydrographic survey in the vicinity of Mendocino City, Cal.—In May, 1883, Lieut. E. D. Taussig, U. S. N., Assistant Coast Survey, was directed to take command of the steamer McArthur, relieving Lieut. W. T. Swinburne; and after making the vessel ready for sea was instructed to proceed to the vicinity of Mendocino City, Cal., and make a hydrographic survey in accordance with a scheme to be sent to him from the office. The progress of this work will be stated in my next annual report.

Continuation of the primary triangulation of the north coast of California.—The scheme for the extension of the triangulation of the north coast of California presented by Assistant A. F. Rodgers as the result of his reconnaissance of the previous year having been accepted, he was instructed in July, 1882, to occupy the stations in the order deemed best as soon as the resumption of the work became practicable.

Having organized his party for the field, he established his camp upon King Peak, Humboldt County, California, a mountain of about four thousand one hundred feet in height, and began observations. This station forms a quadrilateral with the primary stations Great Caspar, Sanhedrim, and Lassic to the south and east, and another quadrilateral with Bear Ridge, Mad River Summit, and Lassic to the north and east. (See Sketch No. 17.)

The season proved exceptionally unfavorable on account of smoke and fog, the former being so dense that for days at a time not even the outlines of mountains four or five miles distant were visible. This constant prevalence of smoke, more or less dense, during the months when access to the elevated peaks of the north coast range is practicable, presents a serious obstacle to the satisfactory progress of the primary triangulation, and some method of overcoming it remains to be devised.

All of the observations of horizontal directions and vertical angles desired were obtained at King Peak by the 28th of October, and arrangements were at once begun by Assistant Rodgers for the occupation of "Lassic," a station six thousand two hundred feet in height. Part of the equipments had been packed down the mountain trail, when a storm of rain, hail, and snow came on, which, for severity and duration, exceeded any that Mr. Rodgers had experienced during twenty-five years of camp life. He was storm-bound with his party for ten days at King Peak. After the storm abated, it was found impracticable to approach "Lassic"; hence the occupation of that station was necessarily deferred to another season.

Assistant Rodgers expresses his high appreciation of the services of Assistant Stehman Forney who aided him in the field work at King Peak, and subsequently in the revision of the records and in the computations of results. In this duty, and in collating the original field-notes relating to descriptions of stations of the north coast tertiary triangulation, Messrs. Rodgers and Forney were occupied at the suboffice in San Francisco until the close of the fiscal year.

SECTION XI.

OREGON AND WASHINGTON TERRITORY, INCLUDING COAST, INTERIOR BAYS, PORTS, AND RIVERS.

(SKETCHES NOS. 2, 17, AND 18.)

Triangulation and topography of the Umpquah River and approaches, Oreg.—In accordance with instructions received toward the close of July, 1882, Assistant L. A. Sengteller left San Francisco

August 11 to begin a survey of the Umpquah River, Oreg. This is the largest stream which enters the Pacific between the Sacramento and Columbia Rivers. A preliminary survey of the entrance was published in 1854.

Through the kindness of the Coos Bay Steamship Company, Mr. Sengteller and his party were landed at Gardiner, on the Umpquah River, August 15, and the next morning he established his camp at Winchester Bay, near the mouth of the river.

Field operations were begun by locating a preliminary base upon the sand dunes lying upon the north bank of the river and extending from the mouth northward. Pending the arrival of the subsidiary base apparatus, a measurement of the base was made with steel tape. Observations of horizontal angles were then begun, a sufficient number of triangulation stations having been established; and about the middle of September the topography of the shores of the river and approaches was commenced. In October the base-line, one thousand one hundred and ninety-two meters in length, was measured with the subsidiary base apparatus. Observations of horizontal angles and plane-table work were continued till November 17, when field operations were closed.

Assistant Sengteller remarks that in crossing the bar all sailing vessels are now towed in and out by powerful tugs, practically removing the dangers attendant upon passing a narrow channel with strong currents and usually heavy swells. Both the bar and entrance are constantly shifting, but at the time of his survey could be safely crossed, except in rough weather, by vessels drawing thirteen to fourteen feet water. The river is navigable to Gardiner, a large mill site, about seven miles above its mouth, for any vessel which can cross the bar, while to Scottsburg, which is practically the head of navigation, and twenty-five miles above its mouth, seven feet may be carried.

About a mile above Gardiner a large tributary—Smith River—empties into the Umpquah, affording about the same advantages of navigation as the main river.

At the beginning of the season dense smoke from the many forest fires raging along the coast materially impeded the progress of the work, and towards the close delays occurred owing to heavy and protracted rains.

The statistics of the partly completed survey are:

Number of angles measured	186
Number of observations made	3,713
Miles of ocean shore line surveyed	4
Miles of shore line of rivers and streams surveyed	11
Miles of trails surveyed	5
Area of topography in square miles	6

After disbanding his field party Assistant Sengteller proceeded to San Francisco, and was occupied until the close of the fiscal year in the preparation and completion of the records and results of his field-work. He will resume the Umpquah River survey at the earliest date practicable.

Continuation of the survey of the Columbia River and tributaries.—At the beginning of the fiscal year Assistant Cleveland Rockwell was engaged in making a topographical survey of the Columbia River lowlands between Saint Helens and the mouth of the Willamette. About three-fourths of the work was completed by the 28th of October, when field operations closed.

Mr. Rockwell was then directed to report for duty at the suboffice in San Francisco, and was engaged there until June in inking and duplicating records of field-work. Early in that month he was instructed to proceed to Portland, Oreg., preparatory to resuming charge of the Columbia River survey. The progress of that work and of other examinations and surveys assigned to Assistant Rockwell will be stated in my next annual report.

Hydrographic surveys of Gray's Harbor and in the Straits of Fuca and Admiralty Inlet.—Having received the requisite instructions, Lieut. T. Dix Bolles, U. S. N., Assistant Coast Survey, proceeded with his party, organized on board of the schooner Earnest, to make a hydrographic survey near Cape Partridge, at the entrance to Puget Sound. He was also directed to make such additional soundings between Point Partridge and New Dungeness as were needed to complete the hydrography, including that of Dallas Bank.

A hydrographic sheet, scale 1–20,000, including in its limits a distance of one mile west of New Dungeness and three miles east of Point Partridge, was begun on the 28th of August, 1882, and

finished about the middle of December. A plane of reference for the soundings was obtained by observations of tides at Port Discovery and at Port Townsend. Upon the completion of this work the vessel was laid up for the winter.

In April, 1883, Lieutenant Bolles was directed to reorganize his party on board of the Earnest, and, as soon as the weather would permit, to proceed to Gray's Harbor, Wash. T., and to Tillamook Bay, Oreg., for the purpose of making resurveys of the bars and as much of the harbors as might be found necessary to correct and complete the charts of those localities. These resurveys were begun at Gray's Harbor May 28, and the party was still occupied in that harbor at the close of the fiscal year.

During the year ending June 30, 1883, the statistics of work reported by the commander of the Earnest are as follows:

Miles run in sounding	274
Angles measured	1,599
Number of soundings	4,212

Lieutenant Bolles had the aid of Ensign J. N. Jordan, U. S. N.

Continuation of the triangulation of Hood's Canal, Puget Sound, Wash. T.—For the more economical and effective prosecution of the survey of Hood's Canal and other waters in Puget Sound, the construction of a steam launch had been ordered. At the beginning of the fiscal year Assistant J. J. Gilbert, under orders to continue the triangulation of Hood's Canal, was at Seattle, Wash. T., acting as inspector on behalf of the United States of the work upon the launch.

Early in September the steam launch, the Fuca, was in readiness, and Assistant Gilbert, having organized his party on board of her, began the triangulation, starting from the last two stations established by Assistant Ellicott in 1881. The season, though sometimes rainy and often foggy and cloudy, was upon the whole a favorable one, and by November 3 the triangulation of the canal was completed to its head.

Assistant Gilbert, in pursuance of instructions, then proceeded to Port Townsend and marked a new station to take the place of the old astronomical station on Point Hudson, the site of which has been covered by recent improvements. The new station was referred to the old, and a description of it made.

Having disbanded his party for the winter, Assistant Gilbert laid up the Fuca at Olympia, Wash. T. (she was afterward removed to Port Townsend), and left for San Francisco, where he reported for duty, as directed, to Assistant George Davidson, and was assigned to service in connection with the Transit of Venus party of observation in charge of that officer. Mr. Gilbert's work in this connection is referred to under the heading of Sections X and XVI.

After the completion of this field duty in December, and until the close of the fiscal year, Assistant Gilbert remained attached to the party of Mr. Davidson, and was employed in office-work relating to the computation of the observations for time and longitude in connection with the Transit, and in the computations of his triangulation of Hood's Canal. He made also a computation of the latitude of Mount Tamalpais from observations made by Subassistant Pratt in 1882, under Assistant Davidson's direction.

All of the records and computations of the Hood's Canal work have been forwarded to the office. Following are the statistics:

Number of angles measured	264
Number of observations made	1,643
Number of secondary readings	107
Number of geographical positions determined	52

SECTION XII.

ALASKA, INCLUDING THE COAST AND THE ALEUTIAN ISLANDS. (SKETCH No. 19.)

Continuation of the hydrographic reconnaissance of the shore-line and harbors of Southeastern Alaska.—In pursuance of instructions directing as early a resumption in the fiscal year as practicable

of the hydrographic surveys in the waters of Southeastern Alaska, Lieut. Commander H. E. Nichols, U. S. N., Assistant Coast Survey, had brought the steamer Hassler, under his command, to an anchorage at the north end of Mary Island, Revillagigedo Channel, on the 6th of July, 1882. His working parties were immediately organized, astronomical observations were made, a base-line was measured on Mary Island, and the triangulation, sketching-in of shore-line, and the hydrography begun.

On August 3 the anchorage was shifted to Hassler Harbor; at this station also astronomical observations were made, and the work was carried on from here until September 27, when the anchorage was shifted to Ward Cove.

The work of the survey of Revillagigedo Channel from Foggy Point to Point Higgins was completed October 6, and on that day the Hassler left Ward Cove for Port Wrangel, anchoring that night in Solstoi Bay, which was sketched and a few soundings taken; the next night an anchorage was made in Steamer Bay, which was also sketched and sounded, and on October 8 the Hassler anchored in Port Wrangel Harbor. A plane-table survey of this harbor was made with numerous soundings. It was Lieutenant-Commander Nichols' intention to carry this survey around Point Highfield in order to settle a disputed point regarding its latitude. Bad weather, however, compelled the postponement of this part of the work, and the original sheet has been retained on board till another season.

Having renewed his supply of coal at Port Wrangel, Lieutenant-Commander Nichols steamed to Port Wrangel Straits October 21, and anchored there to verify the astronomical observation of 1881; then passing through the straits he entered Portage Bay, of which he made a complete survey. Leaving Portage Bay November 6, he anchored the same night in Port Houghton, which was sketched; a few soundings also were taken. Returning by way of Wrangel Straits the Hassler came to anchor off Port Wrangel November 10. Some additions were made to the partly completed survey of that port, but the weather became too stormy for the advantageous prosecution of the work, and on the 20th of November Lieutenant-Commander Nichols started on his return to San Francisco, stopping at Esquimalt for astronomical observations, and at Departure Bay for coal, and arriving at San Francisco December 20.

During the winter the party of Lieutenant-Commander Nichols was engaged in office work, and the steamer was under repairs. Towards the close of March, in pursuance of instructions to resume the survey of the coast-line and inland waters of Southern Alaska, the hydrographic party on board of the Hassler was reorganized, and towards the close of May, 1883, Lieutenant-Commander Nichols had begun a hydrographic survey the in vicinity of Cape Fox. This survey was continued throughout the month of June, and will be connected with work of the previous season. A report of this and other surveys is necessarily deferred until my next annual report. For the season of 1882, the statistics are:

Number of astronomical stations occupied	7
Number of magnetic stations occupied	2
Number of tidal stations established	5
Number of angles measured in triangulation	2,679
Miles run in sounding	476
Angles measured	3,153
Number of soundings	7,910

The following-named officers, attached to the Hassler, rendered effective service in the work of the party: Ensigns F. W. Coffin, C. F. Pond, S. E. Woodworth, W. V. Bronaugh, and F. M. Bostwick, U. S. N. The observations for time, latitude, and azimuth were made by Mr. Fremont Morse, of the Coast and Geodetic Survey.

Acknowledgment has been made by the Alaska Salmon Packing and Fur Company, through its secretary, Mr. David Wilder, for valuable information furnished to the company by Lieutenant-Commander Nichols, with my sanction. His examination of Naha Bay, where the fisheries of this company are located, and his charts of that vicinity, proofs of which were furnished to Mr. Wilder, enabled the company to decide upon the proper point for building a new wharf at which large steamers might load with safety.

Tidal observations continued, with self-registering tide-gauge, at Saint Paul, Kadiak Island, Alaska.—The self-registering tide gauge at the town of Saint Paul, in the island of Kadiak, Alaska, has made a continuous record to date. At the outset of the work, Mr. W. J. Fisher, the observer, was fully instructed by Assistants Davidson and Colonna, and through the liberality and courtesy of the Alaska Commercial Company he erected the tidal house and gauge on the company's wharf. The curves and tabulated results have been very satisfactory; the meteorological record is valuable in giving the percentage of cloudy weather, the rainfall, &c. Sketches of the localities adjacent have been made by the observer. The work is under the direction of Assistant Davidson.

The earthquake waves of the great Java earthquake were exhibited upon the tidal curve at this station, but not so markedly or distinctly as upon the record of the San Francisco gauge.

Determinations of the force of gravity, and relative magnetic intensity at Point Barrow, Alaska.—Reference has already been made under the heading of Section X to the co operation of the Coast and Geodetic Survey with the Signal Office in the establishment of a station of the International Polar Commission at Point Barrow, Alaska, and to the observations for the determination of gravity and of relative magnetic intensity at San Francisco, Cal., made by Mr. R. A. Marr, Acting Assistant, previous to his departure for Point Barrow.

Mr. Marr will transmit full reports of the observations made by him at stations *en route* to Point Barrow and after his arrival there. These will be the subject of mention in my next annual report. He left San Francisco June 16, 1883.

Longitude of Point Barrow, Alaska.—The station of the International Polar Commission at Point Barrow was visited during the summer of 1882 by a relief expedition under the command of Lieutenant Powell, of the Signal Service. Advantage was taken of this trip to determine as closely as practicable the longitude of the Point Barrow Station by the transportation of chronometers. Observations for time, and comparisons of the four chronometers used, were made June 19, 20, and 21, 1882, by Messrs. F. Westdahl and C. B. Hill, of the Coast and Geodetic Survey, at the Lafayette Park Observatory in San Francisco. The rates were again determined by observations at Plover Bay and at Point Barrow on both the outward and return voyages by Lieutenant Powell, and finally by observations, October 27 and 28, on the arrival of the expedition at San Francisco.

On account of very unfavorable weather at the Plover Bay and Point Barrow Stations, but partial observations could be obtained; hence the determination of chronometer rates depending on these observations was not very satisfactory. A discussion of the results by Mr. Winslow Upton, of the Signal Service, gives the following longitude for the Point Barrow Station: $10^h\ 26^m\ 39^s$ west of Greenwich. This value is subject to future revision, and its uncertainty may be greatly diminished by observations of moon culminations at Point Barrow.

SECTION XIII.

KENTUCKY AND TENNESSEE. (SKETCHES NOS. 1, 4, 6, 20, AND 24.)

Occupation of the longitude station at Louisville, Ky., for the determination of the longitude of additional stations in Kentucky by exchanges of telegraphic signals. Observations for the latitude of these stations.—In compliance with a request from Prof. John R. Procter, State Geologist of Kentucky, arrangements were made in May, 1883, for the determination of a number of points in Kentucky in longitude by exchanges of telegraphic signals with the station established in 1879 at Louisville.

Assistant George W. Dean was charged with the direction of the work at Louisville, and Subassistant F. H. Parsons with that at the several stations to be determined in geographical position. The observations at Louisville were made by Mr. Dean's assistant, Carlisle Terry, jr., Aid in the Survey.

Work was begun at Louisville by observations for personal equation between Messrs. Parsons and Terry. For this purpose sixty-five stars were observed on the nights of May 8, 11, 12, and 14. Mr. Parsons then proceeded to Lexington, Ky., and established an astronomical station in the grounds of the Kentucky Agricultural and Mechanical College. Longitude signals were

exchanged with Louisville on the nights of May 24, 25, and 28, and the latitude was determined by observing twenty-eight pairs of stars on three nights.

Louisa, Lawrence County, Kentucky, at the fork of the Big Sandy River, was the next station occupied; exchanges of longitude signals with Louisville were had upon four nights between June 8 and 16, and thirty-four pairs of stars were observed for latitude on five nights.

At the next station, Greensburg, Green County, longitude signals were exchanged with Louisville on the nights of June 22, 23, and 25, and thirty-two pairs of stars were observed for latitude on four nights.

Preparations were then made by Subassistant Parsons for the occupation of a station at Jellico, Whitley County, Kentucky, in order to determine the geographical position of the 59th stone in the Kentucky and Tennessee boundary line. This work will be referred to in my report for the next fiscal year.

Mr. J. W. G. Atkins, Acting Aid, rendered acceptable service in the party of Subassistant Parsons. The statistics of the work at his stations are as follows:

Number of nights of observations for time	19
Number of stars observed for time	290
Number of nights on which longitude signals were exchanged	10
Number of nights of observations for latitude	12
Number of pairs of stars observed for latitude	94

Reference is made under the heading of Section XV to determinations of the latitude of additional stations in Kentucky by Subassistant Parsons in connection with determinations of their longitudes by exchanges of telegraphic signals with the longitude party at Saint Louis, Mo., in charge of Assistant Dean. The original records and reductions of the work at Louisville and at the stations dependent upon it have been transmitted to the office.

In his report, Assistant Dean acknowledges his obligations to Professor Procter for information relating to the stations, and to Mr. Geo. W. Trabue, General Superintendent, and Mr. James Compton, district superintendent, of the Western Union Telegraph, for their friendly co-operation in extending to the astronomical parties every facility in their power.

Reconnaissance for the extension of the triangulation of the State of Kentucky.—In July, 1882, a reconnaissance for the extension of the triangulation of the State of Kentucky was begun by Mr. Carl Schenk, Acting Assistant. His explorations were confined to that part of the State lying to the south and west of Frankfort, between the Ohio and Salt Rivers. Mr. Schenk has submitted a report of his reconnaissance, with a sketch showing the intervisible stations developed by it, and steps will be taken at the earliest date practicable to resume the triangulation.

Occupation of stations in continuation of the triangulation of the State of Tennessee.—Field-work for the extension of the triangulation of the State of Tennessee was begun by Prof. A. H. Buchanan, Acting Assistant, in July, 1882, by the occupation of station Apple, between the Cumberland River and the Chaney Fork of that river. Previous to the occupation of Apple, the signal at Hall Station, which had been destroyed by lightning, was rebuilt.

Observations at station Apple were closed early in August, and the party transferred to Chestnut Mountain, about thirteen miles to the eastward of the town of Sparta, in White County. This station had been previously occupied; its reoccupation was found necessary in order to get observations upon station Walker for the better development of the scheme of triangulation. To see the signal at Walker a cutting of three and a half miles had to be made. Early in September observations upon Walker were finished and work begun at Mount Lore Station, about eight miles to the westward of Sparta. All of the horizontal and vertical angles needed at Mount Lore having been obtained by October 1, the party was transferred to Walker Station October 5. With the completion of work at this station, October 24, field operations closed for the season.

The occupation of Walker finished work at all of the primary stations in the system of triangulation west of the Crab Orchard range of mountains on the eastern edge of the Cumberland Mountain table-land, and connecting the cities of Nashville and Knoxville.

In June, 1883, field-work was resumed by the erection of signals in continuation of the State

triangulation at two stations, and the work was in progress at the close of the fiscal year. The statistics for the season are:

Horizontal angles measured	25
Vertical angles measured	25
Number of observations of horizontal angles	858
Number of observations of vertical angles	750

SECTION XIV.

OHIO, INDIANA, ILLINOIS, MICHIGAN, AND WISCONSIN. (SKETCHES Nos. 1, 4, 20, 21, 22, AND 24.)

Reconnaissance for the primary triangulation near the thirty-ninth parallel extended from West Virginia into Ohio.—An account has already been given under the heading of Section III of this report of the reconnaissance executed by Assistant A. T. Mosman during the autumn and part of the winter of 1882 for the extension of the primary triangulation along or near the thirty-ninth parallel from West Virginia westward into Ohio and Kentucky.

The stations selected in Ohio were Wray, about three miles east of Marion, Marion County; Newcastle, three miles to the northward of Ironton, Lawrence County; Gould, two miles north of Haverhill, Scioto County; and Scioto, about three miles northwest of Portsmouth, Scioto County. Some of these stations were provisionally located; their final incorporation in the scheme will be determined during the next season.

Occupation of stations in continuation of the triangulation of the State of Ohio.—The triangulation of the State of Ohio was advanced from Athens towards Columbus in July, August, and September, 1882, by Prof. R. S. Devol, Acting Assistant. As mentioned in my report of last year, observations at Brooks Station, about thirteen miles northwest of Athens, had been partly completed when the season closed. Between the middle of July and the middle of August, 1882, Brooks Station was re-occupied by Professor Devol. Upon the completion of observations at that point the party was transferred to McDaniel Station, thirteen miles westward from Athens, and the weather being favorable, the work at this station was finished September 9.

The barometric observations begun last year for obtaining the comparative heights of the triangulation points were continued during the season; daily readings of two aneroids being taken at Brooks and McDaniel Stations.

The number of angular measurements at these two stations was one thousand and eighty-five. Records of the observations have been forwarded to the office.

Reconnaissance for the extension of the triangulation of the State of Indiana.—Prof. J. L. Campbell, Acting Assistant, who had been temporarily relieved from the charge of the triangulation of the State of Indiana, in order to assume the direction of works undertaken for the reclamation of the swamp lands of the State, spent parts of the winter and spring of 1882–'83 in a reconnaissance in Clark and Floyd Counties with a view to the expected resumption of geodesic operations in the State at the earliest date practicable in the fiscal year 1883–'84.

The result of his reconnaissance will tend to the enlargement and improvement of the scheme of triangulation.

Determinations of the latitude and longitude of stations in Indiana and Illinois.—A full statement will be made under the heading of Section XV, in the account of the occupation of the station at Saint Louis, Mo., of the exchanges of longitude signals between that station and the stations established in November and December, 1882, at Springfield, Ill., and Indianapolis, Ind. Also, of the observations made for latitude at these points.

Transcontinental line of geodesic leveling extended from Mitchell, Ind., to Saint Louis, Mo., and thence westward to Etlah, Mo.—At the beginning of the fiscal year, Assistant Andrew Braid had nearly completed the line of leveling of precision from Vincennes, Ind., to Mitchell, Ind., the terminal point of the season of 1879. The several sections of this line from the sea-level to Mitchell are:

I. From Sandy Hook, N. J., to Hagerstown, Md.

II. From Hagerstown, Md., to Grafton, W. Va.

III. From Grafton, W. Va., to Athens, Ohio.

IV. From Athens, Ohio, to Mitchell, Ind. Upon reaching the town of Mitchell, primary bench-mark X was cut on the sill of a window of M. N. Moore, as fully described in the record, and the line was started for Saint Louis, following the track of the Ohio and Mississippi Railroad.

Section V, from Mitchell, Ind., to Saint Louis, was run according to the method described in detail by Mr. Braid in Appendix No. 11 to the Report for 1880. It is the same as that employed in the sections previously run, two simultaneous lines being carried in the same direction with the rods at different distances from the instrument, and alternate sections of the line being run in opposite directions to neutralize any tendency to cumulative error due to direction.

At Caseyville, Saint Clair County, Ill., a branch line or offset was run to connect with the north end of the "American Bottom Base," and a bench-mark was established on the head of the copper bolt in the north base monument.

Upon reaching East Saint Louis, arrangements were made for carrying the line of levels across the Mississippi River on the Saint Louis bridge by three independent methods. For this purpose two instruments and two observers were needed, and Subassistant J. B. Weir was directed to report to Assistant Braid. The methods employed were: 1. Leveling over the top of the bridge; 2. Simultaneous sights across the river by two observers stationed on opposite banks; and, 3. Water-level observations.

The results deduced were based entirely upon the two methods first named, and the agreement of the separate results is quite satisfactory.

At Saint Louis Mr. Braid connected with the bench-mark known as the "City Directrix," and established two duplicates of it, in elevation, on the east and west land-piers of the "Great Bridge." These bench-marks are bronze plates an inch thick, and with a surface of eight by twelve inches, set into the granite on the south faces of the east and west piers, respectively, and secured by cement and screw-bolts.

Appendix No. 11, Coast and Geodetic Survey Report for 1882, gives descriptions of these and all other bench-marks established on the line between Sandy Hook and Saint Louis, with a statement of the results of the leveling as made out by Assistant Charles A. Schott.

Before closing field operations in December, Assistant Braid continued the work westward to Etlah, Franklin County, Missouri, about seventy-five miles from Saint Louis. In March, 1883, Assistant Braid was directed to report for duty to R. D. Cutts, Assistant in charge of the office and topography.

Continuation to the eastward of the primary triangulation in Illinois near the thirty-ninth parallel.—The primary triangulation in the State of Illinois along or near the thirty-ninth parallel, which forms part of the geodetic connection between the Atlantic and Pacific coast work, was advanced to the eastward in 1882 by Assistant George A. Fairfield. Arrangements were made early in the fiscal year for the occupation of Hoile Station, near the town of Greenville, Bond County. Before the arrival of Mr. Fairfield, August 7, the observations at Hoile were made by Subassistant J. B. Weir. Signals being needed at Hartlin, Bording, and other stations, a signal-building party was organized and kept constantly occupied till about the middle of October.

All of the observations of horizontal directions at Hoile and the other stations occupied were made by night upon the lights shown by the student lamps, the atmosphere by day being too smoky to admit of satisfactory work. Hoile Station was finished September 3, and the party was transferred to Bording Station, near the town of Carlyle, Clinton County. At Bording, observations were made for horizontal directions, and for time, latitude, and azimuth. All work at this station was completed November 14; and Mr. Fairfield immediately moved his camp to Hartlin Station, about six miles north of the town of Salem, Marion County. The occupation of this station finished field-work for the season, which closed December 3. At that date all of the horizontal directions required had been observed.

Extremely cold weather was encountered while at Hartlin. On the night of December 2 Mr. Fairfield observed for six hours while the mercury stood at 12° above zero (Fahr.). On the 6th of December, the day of the Transit of Venus, the sky was entirely overcast, and the weather comparatively mild until about 4 p. m., when the mercury began to fall very rapidly, the wind blowing

a gale from the northwest. On the 7th the thermometer during the whole day did not rise higher than 2° below zero, and at 10 p. m. it marked 15° below. This severe cold delayed packing, so that it was not till the 13th of December that the tents were stored.

Mr. Fairfield reports four quite perceptible shocks of earthquake during the season: one on September 27, two on October 14, and one on November 14. None of them occurred while he was observing, and no damage was done to any of the high signals.

While field operations were in progress, Subassistant Weir connected Hoile Station with a bench-mark of the transcontinental line of geodesic leveling on the Vandalia Railroad track at the depot in Greenville. He connected also in the same manner (by a line of levels) the station at Bording with the bench-mark established on the east pier of the Ohio and Mississippi Railroad bridge across the Kaskaskia River, near the town of Carlyle. Following are the statistics of work accomplished:

Tripod and scaffold signals erected (one 45 feet high, two 75 feet, one 80 feet)	4
Number of observations for horizontal directions	1,256
Number of nights on which observations for latitude were made	8
Number of pairs of stars observed for latitude	100
Number of nights on which observations for azimuth were made	5
Number of observations for azimuth	136
Number of stars observed for time	90

Assistant Fairfield makes cordial acknowledgment in his report of the efficient and faithful service rendered by the members of his party, Subassistant J. B. Weir and Messrs. Carlile Terry, jr., and T. P. Borden, Aids. Mr. James S. Harper acted as recorder. During the winter Mr. Fairfield was occupied in completing the records and computations of his season's work. All of these have been transmitted to the office. In the spring of 1883 he received instructions to prepare for the resumption of field-work, and at the date at which this report closes had advanced the triangulation in Illinois eastward by the occupation of both primary and secondary stations. In this duty he was assisted by Isaac Winston, Aid, and James S. Harper, recorder. A statement of the progress of this work will be given in my next annual report.

Occupation of stations in continuation of the triangulation of the State of Wisconsin.—The triangulation of the State of Wisconsin was resumed in July, 1882, by Prof. John E. Davies, Acting Assistant. One of the principal objects of the season's work was a determination of the geographical positions of the Beloit Astronomical Observatory and of one or more of the monuments marking the boundary line between Wisconsin and Illinois. Finding that the Beloit Observatory was not visible from any one of the surrounding primary stations, owing to its location in the Rock River Valley, it was decided, after conference with Professor Smith, Director of the Observatory, to determine by careful observation the position of the spire of the Congregational Church, which is a conspicuous object from several primary stations, and to refer this by measurement to the observatory. This work was successfully accomplished. Two of the monuments remaining upon the State line were also determined in position.

An examination of the notes of the original survey of this important boundary line, on file in the State land-office at Madison, Wis., was made by Professor Davies. The results of his geodetic work in the vicinity of the boundary line show discrepancies, amounting in some cases to from one-half to three-quarters of a mile, between the line as actually marked out and the parallel of 42° 30′, which is prescribed as the boundary line by the constitutions of the two States. Additional stations on and near the boundary will have to be occupied to determine its actual position. It has been ascertained that a copy of the original report of survey of the line made by the United States Commissioner to the President of the United States January 29, 1833, is on file in the General Land Office.

The stations occupied by Professor Davies were Janesville, near the town of that name, in Rock County; Plymouth, in Sheboygan County; Wohlford, near Beloit (a subsidiary station); Harmony, about five miles east of Janesville, and Bald Bluff, in Palmyra, Jefferson County, Wis-

consin. From Bald Bluff can be seen two of the triangulation stations established by the United States Lake Survey—Delafield and Waterford. Statistics of the season's work are:

Number of high tripods erected for observing	4
Number of horizontal angles observed	174
Number of vertical angles observed	25
Number of repetitions of horizontal angles	7,182
Number of repetitions of vertical angles	900

Professor Davies has submitted a scheme for the continuation of the triangulation which will be followed in the execution of the work in the next season.

SECTION XV.

MISSOURI, KANSAS, IOWA, NEBRASKA, MINNESOTA, AND DAKOTA. (SKETCHES NOS. 1, 22, AND 24.)

Occupation of the longitude station in Saint Louis, Mo., for the determination of the longitudes of points in Arkansas, Missouri, Nebraska, Kentucky, Indiana, and Illinois by exchanges of telegraphic signals. Determinations of the latitudes of these points.—The scheme of longitude operations adopted for the autumn and part of the winter of 1882 involved the assignment of Assistant George W. Dean to the charge of the station at Saint Louis and to the general direction of the work depending upon it; the assignment of Subassistant C. H. Sinclair to the charge of the corresponding party for primary work, and the detail of Subassistant F. H. Parsons to the charge of a secondary party. Carlisle Terry, jr., Aid, on duty with the party of Assistant Dean, made the observations at the Saint Louis station and exchanged places during the season with Subassistant Sinclair.

Messrs. Dean and Terry completed all preparations needed at the Saint Louis station soon after the middle of September. Kansas City was the first of the primary stations to be determined. Subassistant Sinclair was in readiness there for exchange of signals with Saint Louis by September 15. He had obtained permission of the superintendent of the Board of Education to establish his station in the grounds of the Franklin public school. Unfavorable weather delayed observations for a few days. On the nights of September 21, 23, 26, and 29, longitude signals were transmitted to and from Saint Louis; after which, in order to eliminate personal equation, the observers changed places, and longitude signals were exchanged in their new positions on the nights of October 3, 5, 6, 11, and 13.

For the latitude of the Kansas City station, Subassistant Sinclair made sixty-five observations upon fourteen pairs of stars on six nights.

Between Saint Louis and the station, first occupied by the secondary party in charge of Subassistant Parsons at London, Ky., signals for longitude were exchanged on the nights of September 23, October 4 and 5, and between Saint Louis and the next secondary station, Guthrie, Ky., on the nights of October 13, 14, and 15. Determinations of the latitude of these two stations were made by Mr. Parsons.

Upon the completion of the primary work between Saint Louis and Kansas City, the party at the latter station, under the immediate charge of Mr. Terry, moved to Omaha, Nebr., to exchange signals with Saint Louis. The stone block put down by Assistant Edward Goodfellow to mark the position of the astronomical station established at Omaha in 1868-'69 had been destroyed during the grading of the grounds in 1875, but the lower stone of the north meridian mark, fixed in 1869, was undisturbed, and by measurement back from this mark the center of transit was established almost exactly in the same position as that of 1868-'69. The exchange of longitude signals with Saint Louis began October 20, and by October 27 five nights had been obtained, whereupon the observers changed places and five more exchanges were had between November 6 and November 21.

The party at Saint Louis exchanged longitude signals with Mr. Parsons at Henderson, Ky., on the nights of October 20, 21, and 23, and with the same observer at Little Rock, Ark., on the nights of November 6, 7, and 10. Determinations of the latitude of these two stations were made by Mr. Parsons. Upon his removal to the next station, Springfield, Ill., he exchanged signals

upon the nights of November 20 and 21 with Saint Louis, and on November 23 with the party at Omaha.

It was deemed advisable to include the line Kansas City–Omaha as a check determination, this being the third side of the longitude triangle Saint Louis–Kansas City–Omaha. Arrangements having been made for this work by Assistant Dean, Mr. Terry proceeded to Kansas City with the astronomical instruments and telegraphic apparatus which had been in use at Saint Louis. The first exchange of signals for longitude between Kansas City and Omaha was had on the 26th of November.

Assistant Dean having been relieved from duty at his own request, Mr. Terry was placed in charge of one of the longitude parties upon his recommendation, and continued the work in co-operation with Mr. Sinclair. Between November 29 and December 2 four more night exchanges were had. The observers then changed places, and the final exchanges of the season at the primary stations were obtained between December 10 and January 1. Extremely cold weather at Omaha made the work one of much hardship and exposure.

For the longitude of Indianapolis, the last secondary station occupied by Mr. Parsons, signals were exchanged with Mr. Terry at Kansas City on three nights, closing December 2. Observations for the latitude of the Indianapolis station were made also.

With reference to the instruments and methods employed at the primary stations, Assistant Dean remarks that the new diagonal eye-pieces, having a magnifying power of about ninety five, which had been applied to transits Nos. 4 and 6, were more satisfactory to the observers than the eye-pieces of higher power used during the previous season. All of the stars which were to be observed for determining time were selected from the American Ephemeris and from the Berlin Star Catalogue, particular care being taken to arrange each group, consisting of one circumpolar and four time stars, so that the corrections depending upon the north and south zenith distances should be as nearly equal as possible. Whenever the weather permitted, two groups of five stars were observed at each station (one with transit lamp east, the other west) before exchanging longitude signals. These signals were immediately followed by observing two similar groups, which completed the work for the night.

The arrangements made with the telegraph companies rendered it advisable to limit the time of occupation of the lines to not more than five or ten minutes each night. The clock signals were therefore abandoned, and only arbitrary signals were exchanged.

Assistant Dean has submitted with his report an abstract of results for difference of longitude between the primary stations. He acknowledges the cordial co-operation of Subassistants Sinclair and Parsons and of Mr. Terry in the work of the season. The original and duplicate records and computations have been deposited in the office.

Continuation to the westward of the primary triangulation in Missouri near the thirty-ninth parallel.—Instructions issued to Assistant F. D. Granger, in July, 1882, directed him to proceed to Sedalia, Mo., and organize a party to take the field for the continuation of the triangulation westward from that vicinity, in accordance with the scheme developed by his reconnaissance of the preceding season.

The extreme violence of the storms which prevail in this section of the country made it desirable to avoid building very high tripods at the stations to be occupied, two of those already built having been destroyed. An interior point, "Kendrick," was therefore selected in the quadrilateral Heard–Schnackenberg–High Point Tebo–Knobnoster (see sketch No. 22), and signals of twenty-five feet in height were put up at "Kendrick," and "Knobnoster." At the three stations first named, observing tripods and scaffolds fifty feet in height were erected. At "Caldwell," one of forty feet was put up, and at "Warrensburg" (both stations in the next quadrilateral westward) a pole was placed upon top of the large chimney of the Normal School building.

Observations were begun by the re-occupation of "Heard" for determinations of the primary directions to Schnackenberg, Kendrick, and Knobnoster. This station being completed September 1, the camp equipage and instruments were then forwarded to "Schnackenberg." At this station five primary directions were determined. Upon its completion, "Kendrick" was occupied, observations being begun September 26, and finished October 4, when the party was transferred to "High Point Tebo." Observations upon five primary and four tertiary points having been completed at

this station October 20, "Knobnoster" was next occupied. By November 15, field operations were closed, observations having been obtained upon five primary, two secondary, and three tertiary points. Mr. J. E. McGrath, Aid, and Mr. J. A. Johnson, Acting Aid, served in the party.

During the winter and part of the spring of 1882–'83 Assistant Granger was on duty with the party of Assistant Henry Mitchell, at Boston, Mass. In May, 1883, in accordance with instructions, he re-organized his party in Missouri for continuing the primary triangulation to the westward. Tripod and scaffold signals were erected in advance of the stations to be first occupied, and by the 15th of June all was in readiness for the occupation of station "Normal." The point selected for this station, with the permission of the regents of the school, was the top of the chimney of the Missouri State Normal School building, at Warrensburg. This chimney being nearly ninety feet high, and capped with heavy blocks of sandstone, offered an excellent substitute for the ordinary observing tripod. To the regents and to the principal of the School, Professor Osborne, Mr. Granger expresses his acknowledgments for kindly interest and courtesies.

Observations at "Normal" were nearly completed at the close of the fiscal year. The progress of this work will be referred to in my next annual report. For the fiscal year the statistics are:

Number of observing tripods erected	12
Number of observations for horizontal directions	2,484
Number of double zenith distances	323

Transcontinental line of geodesic leveling carried westward from Saint Louis towards Kansas City, Mo.—Full reference has already been made, under the heading of Section XIV, to the extension of the transcontinental line of geodesic leveling from Mitchell, Ind., to Saint Louis, Mo., and thence towards Kansas City, as far as Etlah, Franklin County, Missouri. The results of this work, which was executed with great care and according to the most approved methods by Assistant Andrew Braid, have been given in a report by Assistant Charles A. Schott, published as Appendix No. 11 to my report for 1882. His discussion takes up the work at its starting-point—Sandy Hook, N. J.—in December, 1881, and closes with the establishment of the primary bench-mark at Saint Louis, Mo., in October, 1882.

SECTION XVI.

NEVADA, UTAH, COLORADO, ARIZONA, AND NEW MEXICO. (SKETCHES NOS. 2, 23, AND 24.)

Primary triangulation in Nevada and Utah, near the thirty-ninth parallel, extended eastward.—In July, 1882, Assistant William Eimbeck was instructed to visit Mount Nebo and Beaver Mountain, in Utah, and to examine the country from these stations with a view of extending to the eastward the primary triangulation across the Wahsatch Mountains. Upon the completion of this duty he was directed to occupy Jeff. Davis Peak, near the thirty-ninth parallel, about fifteen miles to the west of the eastern boundary of Nevada.

In pursuance of this duty Mr. Eimbeck reached Salt Lake City, Utah, early in August, and at once occupied himself with the preparations needed for the reconnaissance from the summits of Mounts Nebo and Beaver, and for the posting of heliotropers upon these elevated summits. Having accomplished this duty, Mr. Eimbeck organized his party for the occupation of Jeff. Davis Peak, a mountain station thirteen thousand one hundred feet in height. Arrangements were made for the transportation of camp outfit and instruments to Lehman's Ranch, in Snake Valley, near the northeastern base of the mountain. Mr. Eimbeck arrived at this ranch on the 22d of September, and, having explored the mountain for the best location of a trail to the top, established two camps: the first at an altitude of seven thousand eight hundred feet, distant about seven miles from the summit; the second about two miles below the summit and at an altitude of eleven thousand feet. The trail having been opened and instruments and camp outfit packed to the top of the peak, heliotroping parties were dispatched to Gosi-ute, Pioche, and White Pine Stations. The work at Jeff. Davis Peak involved the determination of horizontal directions from that station to five other limiting points of a great hexagon, the longest side of which was the line Jeff. Davis Peak–Mount Nebo, one hundred and fifty miles, and the shortest, Jeff. Davis Peak–Gosi-ute, sixty-three miles.

Preparations for observing were delayed by violent storms. On the morning of October 5, after one of these storms, the mercury fell to thirteen degrees above zero, and the snow at camp was a foot deep. The work was pushed, however, at every opportunity of favorable weather, and by November 23 the observations for horizontal directions and for the magnetic elements had been completed. A few days more sufficed to obtain all needful observations for double zenith distances. During November the lowest temperature recorded was twenty degrees below zero (Fahr.). Field operations were closed and the party disbanded early in December. While at Lehman's Ranch, successful observations of the Transit of Venus were obtained by Mr. Eimbeck. For details see Appendix No. 16.

Assistant Eimbeck was efficiently aided throughout the season by Acting Assistant R. A. Marr. During the following winter and spring Mr. Eimbeck was engaged in completing the records and results of his field-work. In April, 1883, he was instructed to extend the reconnaissance to the eastward of the line Mount Nebo–Beaver by occupying such points as would determine definitely the most advantageous figure for continuing the main triangulation across the Wahsatch Mountains. A change in the position of station "Beaver" for the proper development of this figure appearing unavoidable from previous examinations, he was authorized to establish a new station upon one of the neighboring peaks, so located as not to affect the essential geometrical conditions of the great hexagon, and to refer the observed direction Jeff. Davis–Beaver to the new station by the re-occupation of Jeff. Davis Peak.

Assistant Eimbeck reached Salt Lake City in June, and at the date at which this report closes was actively engaged in the prosecution of the reconnaissance.

Reconnaissance for the extension eastward of the primary triangulation near the thirty-ninth parallel in Colorado.—In August, 1882, Assistant F. W. Perkins was directed to organize a party for the continuation to the eastward of the primary triangulation near the thirty-ninth parallel in Colorado and Kansas. Starting from the line Landsman–First View, which marked the terminal points reached in 1881, Mr. Perkins established movable camps at points on the line of the Kansas Pacific Railroad where water could be obtained, and from these camps sent out exploring parties in different directions, with the lightest possible equipment, officers and men sleeping upon the ground without shelter, other than their blankets and buffalo robes, until the latter part of the season.

About twenty-seven miles to the eastward of the starting-points, the boundary line between Colorado and Kansas was crossed. The scheme of triangulation developed by the reconnaissance involves a series of triangle sides extending on both sides of the Kansas Pacific Railroad from the line Landsman–First View to the line Teeter's Hill–Sheridan, about thirty-five miles to the eastward of the Kansas–Colorado boundary. Beyond this line the railroad passes to the north of the thirty-ninth parallel, and the triangulation is developed south of that parallel to the line Walters House–Schmidt's House, about two and a half degrees of longitude to the eastward of the points of departure. The reconnaissance was closed early in November, fourteen primary and nine secondary points having been selected.

With reference to the character of the country over which his work extended, Mr. Perkins remarks that it is a plain, destitute of timber, slightly undulating, and deeply seamed by the streams, which, though dry during the greater portion of the year, have cut deep and wide bottoms, with walls generally rising at a sharp angle to the level of the plain. Owing to the strong winds which sweep over these plains, it is not practicable to use high observing tripods, and in cases where the instrument has of necessity to be mounted even a few feet above the ground, very heavy timber should be used in constructing the tripods.

Mr. Perkins refers in his report to the difficulty of recovering triangulation points in a country practically uninhabited, and almost entirely destitute of well-marked natural objects, and recommends special care in marking the stations, and their careful reference to the corners of the land sections, thus making it the interest of every settler to preserve them. His suggestions as to the details of marking are of much practical value.

Mr. George F. Bird served as Aid in the party; Mr. J. J. Fatzinger as recorder, both in a manner highly satisfactory to their chief.

Duty assigned to Assistant Perkins during the succeeding winter is referred to under the heading of Section VIII.

Observations of the Transit of Venus at Cerro Roblero, near Fort Selden, N. Mex.—In July 1882, Assistant George Davidson, then on special duty in Washington, was appointed by the Transit of Venus Commission chief astronomer of a party to be organized for the observation of the Transit at a station in New Mexico. The meteorological conditions were more likely to be favorable in the interior of the continent, and Assistant Davidson's experience in observing in high altitudes suggested a station embracing these conditions. Upon his return to the Pacific coast he traveled by the southern route to study the best location for a station at a great elevation where all four contacts could be successfully observed.

After a careful personal examination of the country as far south as the latitude of the highest peaks of the Organ Mountains, Mr. Davidson selected as the most available station the summit of Cerro Roblero, an isolated mountain mass rising abruptly to a height of nearly seventeen hundred feet from the right bank of the Rio Grande del Norte, and about four miles from Fort Selden, N. Mex.

Authority for military assistance at Fort Selden having been obtained from General Mackenzie, every support and advice was rendered by Major Bascom, commanding that post at the time of Mr. Davidson's reconnaissance, and subsequently during the occupation of the station by Lieutenant Chance, who succeeded Major Bascom in command.

Having organized his party by the selection of Assistant James S. Lawson and Subassistant John F. Pratt as assistant astronomers, and accompanied by Messrs. D. C. Chapman and T. S. Tappan as photographers, Assistant Davidson arrived at Fort Selden early in November. Instruments, lumber, camp outfit, and all supplies for the observers and men having to be packed on mules to the summit of Cerro Roblero, over a rough mountain trail, extraordinary efforts were required to have all the instruments in position before the day of the Transit. All preparations were completed, however, on the 5th of December, and a programme of operations had been matured for the next day.

Special care had been taken to obtain satisfactory adjustments for the horizontal photoheliograph, a method of observation which in the opinion of the Commission offered as much accuracy as that of observing contacts, and presented many more chances of success. The atmospheric conditions had been gradually becoming more favorable during the first few days in December, and on the 6th the air was clear and all outlines sharply defined. About six minutes before first contact the sun appeared above the crest of the Organ Mountains, and, although at this time the atmosphere was slightly disturbed near those crests, a good observation was obtained, and during the rest of the Transit the steadiness and sharpness of the limbs of the planet and sun were improving.

All four contacts were observed by Assistant Davidson with the five-inch Clark equatorial, No. 862; the first and second contacts were observed by Mr. Lawson, and the third and fourth contacts by Mr. Pratt with the Coast and Geodetic Survey Hassler equatorial, of three inches aperture. The systematic exposure of two hundred and sixteen plates resulted in very superior photographs, every one of which was available for measurement.

Assistant Davidson has submitted an elaborate report of the observation of the Transit, including a statement of the subsequent operations for determining the latitude and longitude of the station, and accompanied by views, drawings, and photographs. This report has been transmitted to the President of the Transit of Venus Commission; a copy of it will be preserved in the archives of the Survey.

SECTION XVII.

IDAHO, WYOMING, AND MONTANA TERRITORIES. (SKETCH No. 2.)

Completion of the work of verification of the northern boundary of Wyoming Territory.—As already stated in Part I of this report, the work of verification of the northern boundary of Wyoming Territory for the Interior Department was completed in the field at the close of August, 1882. Assistant B. A. Colonna, to whom this important duty was intrusted, has made to me a full report

accompanying the records and results of his work for transmission to the Department of the Interior. His examinations on the ground involved determinations of time, latitude and azimuth, and of the magnetic declination, relative total intensity, and dip at the northeast corner of Wyoming Territory. Thence he prolonged a tangent west, to and beyond the little Missouri River, testing the alignment of the mile-posts on the boundary and their latitude. Observations were then made for time, latitude, azimuth, and the magnetic elements at the Little Missouri River, near mile-post 329, thus checking the work and uniting the two stations by means of the tangent prolonged from the northeast corner. Similar determinations were made at the three hundred and sixth mile-post; in the vicinity of the two hundred and eighty-third–two hundred and eighty-fourth mile-post; at the one hundred and eighty-fifth mile post, and at the forty-second mile post. The seventeenth mile-post was examined, and various measures were made to check distances between the several mile-posts.

Mr. Colonna expresses his great obligations to the commander of the escort furnished to him at my request—Capt. F. M. Gibson, of the Seventh Cavalry, United States Army; also to his second in command, Lieut. B. D. Spillman. These gentlemen afforded valuable assistance in the conduct of the expedition.

Mr. Colonna's report makes special mention of the able and faithful service rendered in his party by Mr. T. P. Borden, Aid. For a part of the time Mr. C. D. Gedney was attached to the party. He has duplicated the records and results of the work, and furnished sketches to accompany the field-notes.

In reference to the service rendered to the Interior Department by this special investigation, the following letter was received from the Secretary of the Interior:

"DEPARTMENT OF THE INTERIOR,
"*Washington, December* 7, 1882.

"SIR: Your communication of the 4th instant containing the result, under date of the 29th ultimo, of the investigation of Mr. Rollin J. Reeves' survey of the northern boundary of Wyoming, conducted in the field by your assistant, Mr. Colonna, in accordance with my predecessor's request of August 25, 1881, is received.

"This Department feels under great obligations to your office for the services rendered, because of the thoroughness of the examination of the line of survey and the fullness of the field-notes, which leave in the possession of this Department a complete history of the line for future use. I desire, therefore, to put on record my appreciation of your valuable aid in establishing this important boundary line, and of the ability and thoroughness with which the investigation was made.

"Very respectfully,

"H. M. TELLER,
"*Secretary.*

"Prof. J. E. HILGARD,
"*Superintendent of United States Coast and Geodetic Survey.*

A communication of similar import was received from the Commissioner of the General Land Office.

SPECIAL OPERATIONS.

Observations of the Transit of Venus at Auckland, New Zealand. Also, determinations of the Force of Gravity at the Transit of Venus Station and at stations in New South Wales, British India, and Japan.—In Part I of this report, reference was made to the town of Auckland, New Zealand, as one of the stations selected by the Transit of Venus Commission for the observation of the Transit. Assistant Edwin Smith having been appointed to take charge of the expedition to New Zealand, reported for that duty August 7. Prof. H. S. Prichett, of the Washington University, Saint Louis, Mo., was attached to the party as assistant astronomer, and Messrs. Augustus Story and Gustave Thielkuhl as photographers.

Leaving San Francisco September 19, the expedition arrived at Auckland October 15. With the permission of the authorities of the city of Auckland, Mr. Smith established his station on a reservation known as "The Domain," in the eastern portion of the city. Its geographical position

was determined by the assistant surveyor-general, Mr. Percy Smith, who connected it with the New Zealand Trigonometrical Survey. His results were, approximately: latitude 36° 51′ 55″ south, longitude 174° 46′ 47″ east of Greenwich. The height of the ground at the observing pier was found to be two hundred and sixty-two feet above high water.

While preparations for the Transit were in active progress, the latitude was obtained directly by observations upon eleven pairs of stars, and the longitude by exchanges of telegraphic signals with an English party of observation at Burnham, this party having exchanged signals with the observatory at Sydney, New South Wales.

On the day of the Transit the weather was clear at intervals only, and success but partial. The sun rose in clouds; these partly dispersed as Venus advanced on the sun's disk, and seventy-four negatives were secured with the horizontal photoheliograph; but at no time during the Transit was the sun free from clouds, and all of the photographs show their presence. A few moments before third contact the clouds became quite thin, and both third and fourth contacts were observed by Messrs. Smith and Prichett with their equatorial telescopes.

A full report of the observations has been prepared for transmission to the president of the Transit of Venus Commission. Mr. Smith has also prepared a report of the determinations of the force of gravity at Auckland with the three Kater invariable pendulums. These pendulums were swung continuously from November 27 to December 4, inclusive, in a small brick building known as the "Block House," near the Transit of Venus Station.

Leaving Auckland towards the close of December, 1882, Messrs. Smith and Prichett arrived at Sydney, New South Wales, January 2, 1883. Every facility for pendulum work was afforded to the party by the kindness of H. C. Russell, esq., Director of the Sydney Observatory. The pendulums were swung in the cellar of the observatory under the transit room from January 5 to January 11, inclusive. The conditions of observation were exceedingly favorable, the room being dry and the changes of temperature during the experiments not exceeding three degrees Fahrenheit.

From Sydney Mr. Smith proceeded, by way of Brisbane, Australia, and Batavia, Java, to Singapore, Straits Settlements, British India. Permission was granted by the governor of the Straits Settlements to swing the pendulums at the European Hospital. The station was established in the laboratory of the hospital, where the pendulums were swung continuously from March 2 to March 7 inclusive. Acknowledgment is made by Mr. Smith of the hospitable attentions received from Dr. Simon, in charge of the hospital, and for liberal assistance rendered by Captain McCallum, R. E., in charge of the office of the Colonial Engineers. At the request of this officer a meridian line was established for the use of the Colonial Survey.

Proceeding thence to Hong-Kong, China, *en route* to Yokohama and Tokio, Japan, President Kato, of the University of Tokio, offered every facility for the observations, and caused a stone pier to be erected for the apparatus in a new fire-proof building but a short distance from the physical laboratory. A continuous series of observations was secured from April 24 to May 1 inclusive. Professor Paul, of the Tokio University, took great interest in the success of the work, and rendered personal assistance and hospitality to the observers.

Leaving Tokio May 15 the party arrived at San Francisco May 31, and, as already mentioned under the heading of Section X, made a series of gravity determinations at the station selected there by Assistant Davidson. To complete the series it is intended to swing these pendulums at the Smithsonian Institution, where they had previously been swung by Lieutenant-Colonel Herschel, Royal Engineers.

Observations in connection with those made at Caroline Island, South Pacific Ocean, of the Total Eclipse of the Sun, May 6, 1883. Also determinations of the Force of Gravity at the Eclipse station, and at stations in the Sandwich Islands, and in San Francisco.—The special expedition organized for the observation of the Total Solar Eclipse at Caroline Island in the South Pacific, mention of which was made in Part I of this report, was placed in charge of Prof. Edward S. Holden, Director of the Washburn Observatory. Mr. E. D. Preston, of the Coast and Geodetic Survey, was ordered to report to Professor Holden as a member of the expedition. The United States ship Hartford conveyed the party to Caroline Island, arriving there on the 20th of April.

Preparations for the work were at once begun, each observer having had a special duty allotted to him by Professor Holden. To Mr. Preston were assigned the determinations of time for the

eclipse, observations for latitude by the method of equal zenith distances, and the observation of the four contacts. As given approximately by the field computations, the geographical position of the station was found to be: Latitude 10° 00′ 01″ south; longitude 10^h 00^m 56^s west of Greenwich. The longitude is from the observations of Mr. Winslow Upton, of the Signal Service, who was a member of the party.

On the day of the eclipse the weather was clear during totality, except a slight haze for a minute or two at beginning. All four contacts were observed by Mr. Preston, using a small telescope of about two and a half inches aperture and three feet in focal length, with a magnifying power of about 115.

Referring to the appearance of the first ray of sunlight after the darkness of the long totality, Mr. Preston remarks that it was like a flash of the electric light as contrasted with the intense color of the chromosphere on the western edge of the moon for the few seconds preceding third contact.

In addition to the observations pertaining to the eclipse, Mr. Preston was charged, on behalf of the Coast and Geodetic Survey, with determinations of gravity at Caroline Island, and at stations in the Sandwich Islands on his homeward voyage. For this purpose, pendulum No. 3 was swung on eight nights at the Eclipse station. On the 9th of May, Mr. Preston left the Caroline Islands for Honolulu on board the Hartford, and upon his arrival received instructions to determine the force of gravity at the station on the island of Maui, occupied by De Freycinet in 1819. At this station (Lahaina) the pendulum was swung on ten nights, and the latitude determined by one hundred and fourteen observations on thirty-five pairs of stars. A second station was occupied at Honolulu (Oahu) where the pendulum was swung during three consecutive days and nights, and a limited number of observations for latitude were obtained, but little time being available before the departure of the steamer for San Francisco.

Upon reaching San Francisco July 9, comparative determinations of gravity were begun at the station established there by Assistant Davidson. Mr. C. B. Hill, of Mr. Davidson's party, was assigned to aid Mr. Preston in his observations. The work was prosecuted between July 15 and 27, with many interruptions from unfavorable weather.

Mr. Preston acknowledges the efficient assistance of Ensign S. J. Brown, U. S. N., in the work at the Caroline and Sandwich Islands, and expresses his obligations for many kind attentions received from Mr. H. Turton, of Lahaina; from W. D. Alexander, esq., Superintendent of the Hawaiian Government survey, and from the Governor of Oahu.

An abstract of the report of Mr. Preston appears as Appendix No. 17.

Tidal observations at Honolulu, Sandwich Islands.—In order to obtain a record of the Sandwich Island tides for comparison with the tides of the Pacific coast, a self-registering tide-gauge, loaned by the Coast Survey to the Superintendent of the Hawaiian Government survey, has been kept in operation under the direction of that officer since June, 1877. Records from this tide-gauge are sent from time to time to this office, the latest received bringing up the series to near the close of July, 1882. In connection with the tidal records from the self-registering gauges on San Francisco Bay and at Kadiak Island, Alaska, this series will have a special value.

COAST AND GEODETIC SURVEY OFFICE.

It will appear from the report of Assistant Richard D. Cutts, in charge of the Office and Topography (Appendix No. 4), that all of the material received from the field has been put rapidly into shape for record and publication. Consideration has been given and experiments made with a view to the introduction of improvements in methods and processes. The demands upon the office for the charts and other publications of the Survey are increasing year by year, as also are applications for special information, transcripts from original surveys, &c., from persons not connected with the work. A tabular statement of information furnished is given in Appendix No. 3.

To the report of Assistant Cutts are appended the reports of the chiefs of the several office divisions. Accompanying these are tables giving the titles of the charts and engraved plates begun, completed, and continued during the year; also a list of the publications of the Survey received from the Government Printer and an account of their distribution.

Assistant Cutts refers to the collections of geographical data in the office which are now available for the construction of a map of the United States, and suggests that, under the authority of Congress, steps be taken toward the construction of such a map, based upon a scientific framework and executed upon an appropriate scale. This suggestion meets with my cordial approval.

The progress made in the preparation for publication of the third volume of the Atlantic Coast Pilot (Division C), including the coast from New York to the Chesapeake, has been already referred to in Part II of this report, under the heading of Section II.

Numerous additions have been made to our knowledge of Southeastern Alaska since 1879; it has been necessary therefore to revise portions of the text of the manuscript of the Coast Pilot of Alaska and to make additions or corrections to the charts in order to bring them up to date. Assistant W. H. Dall has been engaged in this work during the past fiscal year, his knowledge of that coast acquired by his own long service there making him peculiarly fitted for it. The manuscript is now in the hands of the printer. It relates to or describes about 8,800 miles of shore-line. The collection of material has compelled frequent reference to works in the Russian, Spanish, German, French, and other languages, in order that no information of value might be overlooked.

Upon the request of four committees of Congress, special information on the Alaskan region was furnished to them, under my direction, by Mr. Dall; responses were also made to a large number of requests relating to this region by private individuals. During the period from August 18, 1882, to April 30, 1883, Mr. Dall was aided by Mr. Isaac Winston.

Mr. W. B. Morgan has continued in the position of disbursing agent of the Survey. Mr. Morgan has been assisted by Messrs. John W. Parsons and W. A. Herbert as accountants; the latter during the fiscal year, the former since March last.

In the preparation of this report I have had the aid of Assistant Edward Goodfellow. The clerical duties in my office have been performed by Messrs. W. B. Chilton and C. D. Gedney.

Respectfully submitted.

J. E. HILGARD,
Superintendent.

Hon. C. J. FOLGER,
Secretary of the Treasury.

PART III.

APPENDICES.

Appendix No. 1.

***Distribution of surveying** parties upon the Atlantic, Gulf of Mexico, and Pacific coasts, and the interior of the United States during the fiscal year 1882–'83.*

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION I.				
Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island, including coast and seaports, bays and rivers.	No. 1	Triangulation and topography.	C. H. Boyd, assistant; E. L. Taney, aid.	Triangulation and topography of Machias Bay and River, Me. (See also Section VIII.)
	2	Topography	Eugene Ellicott, assistant	Topography of islands in Moos-a-bec Reach and shore line of Chandler's Bay, Me. (See also Sections III and VI.)
	3	Topography	A. W. Longfellow, assistant	Topography of the shores of Pleasant River, Me.
	4	Hydrography	Lieut. H. G. O. Colby, U. S. N., assistant; Ensigns David Daniels, O. G. Dodge, and A. Jeffries, U. S. N.	Hydrographic surveys in Narraguagus and Pigeon Hill Bays; soundings off Gouldsborough Bay and in Dyer's Bay and Rockland Harbor, Me.
	5	Tidal observations	J. G. Spaulding	Series of tidal observations with self-registering tide-gauge continued, and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay.
	6	Triangulation	Richard D. Cutts, assistant; John A. McNicol.	Primary triangulation for the connection of the station upon Mount Washington, N. H., with the triangulation of Maine, and of the Hudson River and Lake Champlain.
	7	Geodetic	Prof. E. T. Quimby, acting assistant.	Occupation of stations for determining points in the triangulation of New Hampshire.
	8	Geodetic	Prof. V. G. Barbour, acting assistant.	Stations occupied in continuation of the triangulation of the State of Vermont.
	9	Deep-sea soundings.	Lieut. Commander W. H. Brownson, U. S. N., assistant.	Line of deep-sea soundings from off Nantucket across the Gulf Stream. (See also Sections II and VI.)
	10	Tidal observations	....	Observations continued at Providence, R. I., with a self-registering tide-gauge loaned to the city engineer.
SECTION II.				
Connecticut, New York, New Jersey, Pennsylvania, and Delaware, including coast, bays, and rivers.	No. 1	Deep-sea and off-shore soundings.	Commander J. R. Bartlett, U. S. N., assistant; Lieut.-Commander W. H. Brownson, U. S. N., assistant; Lieut. G. W. Mentz, U. S. N.; Ensign H. S. Knapp, U. S. N.	Deep-sea soundings from vicinity of Montauk Point to the Bermuda Islands, and lines of soundings normal to coast off south shore of Long Island. (See also Sections I and VI.)
	2	Hydrography	Lieut.-Commander W. H. Brownson, U. S. N., assistant; Lieut. H. B. Mansfield, U. S. N., assistant; Master C. R. McWinslow, U. S. N.; Ensign W. B. Caperton, U. S. N.; Midshipmen W. C. Canfield, R. S. Sloan, and Wm. Truxtun, U. S. N.	Hydrography of eastern entrance to Long Island Sound. (See also Sections I and VI.)

APPENDIX No. 1—Continued.

Stations.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION II—Continued.				
	No. 3	Tidal observations	J. M. Conley	Self-registering tide-gauge established on the breakwater, Block Island.
	4	Triangulation	Spencer C. McCorkle, assistant	Re-establishment of points of old triangulation, and determination of new points from Watch Hill westward for resurvey of Long Island Sound. (See also Section VIII.)
	5	Topography	Edwin Hergesheimer, assistant; A. E. Burton, aid.	Topographical survey of Fisher's Island, Long Island Sound.
	6	Hydrography	Lieut. Richardson Clover, U. S. N., assistant; Lieut. A. V. Wadhams, U. S. N., assistant; Ensign L. K. Reynolds, U. S. N.; Midshipman Harry Phelps, U. S. N.; W. C. Willenbucher.	Hydrographic resurvey of Fisher's Island Sound and New London and Stonington Harbors.
	7	Topography	W. C. Hodgkins, subassistant	Topographic resurvey of north shore of Long Island Sound to eastward of Thames River. (See also Section VIII.)
	8	Topography	W. H. Dennis, assistant	Topographic resurvey of New London and vicinity.
	9	Tidal observations	E. Koch	Self-registering tide-gauge established at Fort Trumbull, New London, Conn.
	10	Triangulation	C. H. Van Orden, subassistant	Re-establishment of points of former triangulation, and determination of new points on south shores of Long Island Sound in vicinity of Montauk Point and Gardiner's Bay. (See also Section VIII.)
	11	Topography and hydrography.	Charles Hosmer, assistant; Master J. C. Fremont, jr., U. S. N.; Ensign A. F. Fechteler, U. S. N.	Topographic and hydrographic resurvey of eastern part of south shores of Long Island Sound.
	12	Hydrography	Lieut. Edward M. Hughes, U. S. N., assistant; Midshipmen F. W. Kellogg and A. A. Ackerman, U. S. N.	Hydrographic resurvey of Gardiner's Bay and approaches, south coast of Long Island Sound. (See also Section IX.)
	13	Triangulation	J. A. Sullivan, acting assistant	Determination of the geographical position of the new observatory of Yale College.
	14	Triangulation	Gershom Bradford, assistant; H. R. Garland.	Points determined for the resurvey of the north shore of Long Island Sound from vicinity of Bridgeport, Conn., westward.
	15	Special operations	F. H. Gerdes, assistant	Recovery and marking of triangulation points on the north shore of Long Island between Hempstead Harbor and Horton's Point, N. Y.
	16	Topography and hydrography.	Charles Hosmer, assistant; Master J. C. Fremont, jr., U. S. N.; Ensign A. F. Fechteler, U. S. N.	Topographic and hydrographic resurvey of the western part of Long Island Sound in vicinity of Throg's Neck.
	17	Hydrography	Lieut.-Commander E. B. Thomas, U. S. N., assistant; Master F. A. Wilner, U. S. N.; Ensigns H. M. Witzel, J. M. Orchard, and C. S. McClain, U. S. N.	Hydrographic resurvey of the approaches to New York Harbor.
	18	Tidal observations	F. W. Shepheard	Series of tidal observations continued with self-registering tide gauge at Sandy Hook, N. J.
	19	Force of gravity	Charles S. Peirce, assistant; E. D. Preston and F. B. Hall.	Determinations of the force of gravity at Hoboken, N. J., and at Albany, N. Y. (See also Sections III, V, and VI.)
	20	Off-shore hydrography and deep-sea sounding.	Lieut. Commander W. H. Brownson, U. S. N., assistant; Lieut. G. W. Mentz, U. S. N.; Ensigns H. C. Wakenshaw, W. M. Constant, and Harry S. Knapp, U. S. N.	Hydrography off south coast of Long Island, and lines of deep-sea soundings in the vicinity of New York Bay entrance. (See also Sections I and VI.)
	21	Verification of hydrography.	J. S. Bradford, assistant	Verification of hydrography for the Atlantic Coast Pilot.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION II—Continued.				
	No. 22	Leveling operations.	O. H. Tittmann, assistant; J. W. D. Atkins and W. O. Jones.	Leveling operations for connecting the Coast Survey reference mark at Albany, N. Y., with the primary triangulation station on Mount Mansfield, Vt. (See also Section VI.)
	23	Triangulation....	C. O. Boutelle, assistant; J. B. Baylor, subassistant; J. B. Boutello, extra observer.	Primary triangulation across the State of New York for connecting the triangulation of Hudson River and Lake Champlain with that of the survey of the Great Lakes.
	24	Triangulation.....	Prof. E. A. Bowser, acting assistant.	Continuation of the triangulation of the northern part of the State of New Jersey.
	25	Topography	C. M. Bache, assistant............	Additions of topographical details to original sheets of survey of the New Jersey coast between the highlands of Navesink and Tom's River. (See also Section III.)
	26	Triangulation.....	A. T. Mosman, assistant; W. B. Fairfield, extra observer.	Triangulation of Delaware Bay and River. (See also Sections III and XIV.
	27	Physical hydrography.	Henry Mitchell, assistant; H. L. Marindin, assistant; F. D. Granger, assistant; J. A. Sullivan.	Physical hydrography of Delaware Bay and River.
	28	Hydrography.....	H. L. Marindin, assistant; W. I. Vinal, subassistant (part of season); Ensign E. M. Katz, U. S. N.; Midshipmen J. A. Dougherty and L. S. Van Duzen, U. S. N.	Hydrographic resurvey of Delaware Bay and River.
	29	Hydrography.....	Lieut. H. B. Mansfield, U. S. N., assistant; Lieut. Hugo Osterhaus, U. S. N., assistant.	Hydrographic resurvey of Delaware Bay and River.
	30	Topography	W. I. Vinal, subassistant..........	Resurvey of topography in vicinity of Cape Henlopen, Del.
	31	Hydrography.....	Lieut. G. C. Hanus, U. S. N., assistant; Master W. G. Cutler, U. S. N.; Ensigns E. F. Leiper and G. R. French, U. S. N.	Continuation of hydrographic resurvey of lower Delaware Bay.
	32	Topography	R. M. Bache, assistant.	Topographic resurvey of the New Jersey shore of Delaware River and Bay continued.
	33	Topography	C. T. Iardella, assistant	Continuation of the topographic resurvey of the west shore of Delaware River and Bay from Newcastle southward.
	34	Geodetic..........	Mansfield Merriman, acting assistant.	Reconnaissance and extension westward of the triangulation of the State of Pennsylvania.
	35	Special operations.	C. H. Sinclair, subassistant; C. H. Van Orden, subassistant.	Determination of boundary line between Pennsylvania and West Virginia. (See also Sections III and XIV.)
SECTION III. **Maryland, Virginia, and West Virginia, including bays, seaports, and rivers.**	No. 1.	Determinations of gravity.	C. S. Peirce, assistant; E. D. Preston, Carlisle Terry, jr., and R. A. Marr, aids.	Determinations of gravity by pendulum experiments at Baltimore and at Washington. (See also Sections II, V, and VI.)
	2	Transit of Venus..	Charles A. Schott, assistant; B. A. Colonna, assistant; J. G. Porter.	Observations of the Transit of Venus of December 6, 1882, at Washington, D. C.
	3	Topography	John W. Donn, assistant; D. B. Wainwright, assistant.	Continuation of the detailed topographical survey of the District of Columbia.
	4	Special operations.	H. G. Ogden, assistant	Examination of the monuments of the Trial Base Line at Fort Myer reservation, Va.
	5	Topography	Eugene Ellicott, assistant	Special survey for the Fish Commission near the Great Falls of the Potomac. (See also Sections I and VI.)
	6	Topography	C. M. Bache, assistant............	Continuation of topographic survey of the south shore of Hampton Roads, between Craney Island and Nansemond River. (See also Section II.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION III—Continued.				
	No. 7	Hydrography	Master John C. Fremont, jr., U. S. N., assistant; Ensigns A. F. Fechteler and F. W. Kellogg, U. S. N.	Current observations at stations near the entrance of Chesapeake Bay and thence southward. (See also Section VI.)
	8	Determination of latitude and longitude.	C. H. Sinclair, subassistant; F. H. Parsons, subassistant.	Determination of the longitude of the University of Virginia, Charlottesville, by exchange of telegraphic signals with Washington, and of the latitude of the Charlottesville station. (See also Sections II, VIII, XIII, XIV, and XV.)
	9	Geodetic connection.	C. H. Sinclair, subassistant.	Connection of the astronomical station at the University of Virginia, with the primary triangulation. (See also Sections II and XV.)
	10	Special reconnaissance and triangulation.	H. F. Walling	Reconnaissance, triangulation, and hypsometric observations in the region about Washington, D. C., for the construction of a general map.
	11	Reconnaissance ..	A. T. Mosman, assistant; W. B. Fairfield, extra observer.	Reconnaissance for the extension of the primary triangulation near the thirty-ninth parallel westward, in West Virginia, Ohio, and Kentucky. (See also Sections II and XIV.)
SECTION IV.				
North Carolina, including coast, sounds, seaports, and rivers.	No. 1	Deep-sea soundings and temperatures.	Commander J. R. Bartlett, U. S. N., assistant; Lieut G. W. Mentz, U. S. N.; Ensign H. S. Knapp, U. S. N.	Lines of deep-sea soundings and temperatures off the Atlantic coast of the United States. (See also Section II.)
	2	Hydrography	Lieut. F. A. Wilner, U. S. N., assistant; Ensigns F. H. Sherman and Harry Phelps, U. S. N.	Hydrographic surveys of Cape Fear River entrance and in Croatan and Pamplico Sounds.
SECTION V.				
South Carolina and Georgia, including coast, sea-water, channels, sounds, harbors, and rivers.	No. 1	Hydrography	Lieut. J. T. Sullivan, U. S. N., assistant: Ensigns W. H. Allen, E. N. Fisher, and J. P. Parker, U. S. N.	Hydrographic survey in the vicinity of Cape Romain, S. C. (See also Section II.)
	2	Telegraphic longitudes and pendulum observations.	Charles S. Peirce, assistant; E. D. Preston.	Occupation of the station at Savannah, Ga., for the determination of the longitude of Saint Augustine, Fla., by exchange of telegraphic signals. (See also Sections II, III, V, VI.)
SECTION VI.				
Peninsula of Florida, from Saint Mary's River on the east coast to Anclote Keys on the west coast, including the coast approaches, reefs, keys, seaports, and rivers.	No. 1	Hydrography	Lieut. E. D. F. Heald, U. S. N., assistant; Lieut. David Daniels, U. S. N.; Ensigns O. G. Dodge and Alfred Jeffries, U. S. N.	Hydrographic resurvey of Saint John's River and bar.
	2	Telegraphic longitudes.	Charles S. Peirce, assistant, in co-operation with Col. F. Perrier, Director of the French geographic service and chief of party for observation at Saint Augustine of the Transit of Venus; E. D. Preston.	Determination of the longitude of the Transit of Venus station at Saint Augustine by exchange of telegraphic signals with Savannah. (See also Sections II, III, and IV.)
	3	Reconnaissance...	Eugene Ellicott, assistant	Reconnaissance of Saint John's River from Lake Monroe to Lake Washington. (See also Sections I and III.)
	4	Triangulation, topography, and hydrography; observations for azimuth and of magnetic declination, dip, and intensity.	B. A. Colonna, assistant; T. P. Borden and E. L. Taney, aids; W. B. Fairfield, extra observer; Ensign Edward Simpson, U. S. N. (part of season).	Survey of the eastern coast of Florida from Indian River Inlet southward. (See also Section XVII.)
	5	Triangulation, topography, hydrography, and observations for azimuth.	O. H. Tittmann, assistant; J. B. Weir, subassistant; Ensign E. M. Katz, U. S. N.; Midshipmen J. A. Dougherty and L. S. Van Duzer, U. S. N.	Survey of the shores and lagoons of East Florida from Key Biscayne northward. (See also Section II.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
Section VI—Continued.	No. 6	Hydrography.....	Lieut. H. B. Mansfield, U. S. N., assistant; Ensigns W. B. Caperton, H. M. Wetzel, J. M. Orchard, and C. S. McClain, U. S. N.	Hydrographic survey between Jupiter Inlet and Key Biscayne. (See also Section II.)
	7	Current observations.	Lieut. J. C. Fremont, jr., U. S. N., assistant.	Observations of currents at stations off Jupiter Inlet, Fla. (See also Section III.)
	8	Deep-sea soundings.	Lieut. Commander W. H. Brownson, U. S. N., assistant; Lieut. G. W. Mentz, U. S. N.; Masters Henry Morrill and Lucian Flynne, U. S. N.; Ensigns H. C. Wakenshaw, W. M. Constant, and H. S. Knapp, U. S. N.	Deep-sea soundings, with serial temperatures, between the Bahamas and the Bermudas. (See also Sections I and II.)
	9	Topography and hydrography.	Joseph Hergesheimer, subassistant; J. B. Boutelle, extra observer.	Topographic and hydrographic survey of the west coast of Florida between Charlotte Harbor and Tampa Bay.
	10	Hydrography.....	Lieut. H. B. Mansfield, U. S. N., assistant.	Hydrography off the west coast of Florida to the northward and southward of Tampa Bay. (See also Section II.)
Section VIII. **Alabama, Mississippi, Louisiana, and Arkansas, including Gulf coast, ports, and rivers.**	No. 1	Reconnaissance...	Spencer C. McCorkle, assistant; W. O. Jones, acting aid.	Reconnaissance for the connection of the Gulf coast triangulation in Mobile Bay, Ala., and vicinity, with the primary triangulation at or near Atlanta, Ga. (See also Section II.)
	2	Topography and hydrography, with supplementary triangulation.	C. H. Boyd, assistant; Midshipman James C. Drake, U. S. N.; J. De Wolf, extra observer.	Continuation of the survey of the coast of Louisiana west of the Mississippi River. (See also Section I.)
	3	Triangulation, topography, and hydrography; measurement of base and observations for latitude and azimuth.	F. W. Perkins, assistant; W. C. Hodgkins, subassistant; G. F. Bird, aid; Lieut. Lucian Flynne, U. S. N., assistant.	Survey of the coast of Louisiana from Sabine Pass eastward. (See also Section XVI.)
	4	Telegraphic longitudes.	F. H. Parsons, subassistant	Determination of the longitude of Little Rock, Ark., by exchange of telegraphic signals with Saint Louis. (See also Sections III, XIII, and XIV.)
Section IX. **Texas and Indian Territory, including Gulf coast, bays, and rivers.**	No. 1	Hydrography.....	Lieut. E. M. Hughes, U. S. N., assistant; Lieut. C. McR. Winslow, U. S. N.; Ensigns T. M. Brumby, W. C. Canfield, and Wm. Truxtun, U. S. N.	Hydrography of the coast of Texas from Galveston entrance eastward.
	2	Triangulation, topography, measurement of base, and determination of azimuth.	R. E. Halter, assistant; J. E. McGrath, aid.	Topography of the shores of Nueces Bay; triangulation in the vicinity of Matagorda Bay, measurement of base of verification, and observations for azimuth.
Section X. **California, including the coast, bays, harbors, and rivers.**	No. 1	Magnetic observations.	Marcus Baker, acting assistant; Werner Suess.	Establishment of a magnetic, self-registering record station at Los Angeles, Cal.
	2	Triangulation	James S. Lawson, assistant.......	Continuation of the primary triangulation northward from Point Concepcion. (See also Section XVI.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION X—Continued.	No. 3	Hydrography	Lieut. W. T. Swinburne, U. S. N., assistant; Lieuts. J. B. Milton and W. P. Elliott, U. S. N.; Master F. H. Lefavor, U. S. N.; Midshipman P. B. Bibb, U. S. N.	Hydrographic survey from Monterey southward.
	4	Telegraphic longitudes and observation of the Transit of Venus	George Davidson, assistant; J. J. Gilbert, assistant; E. F. Dickins, subassistant; C. B. Hill.	Observations at San Francisco, Cal., for the determination of the longitude of the Transit of Venus station, near Fort Selden, N. Mex., by exchange of telegraphic signals. Observations of the Transit at San Francisco. (See also Section XVI.)
	5	Hydrography	Louis A. Sengteller, assistant; Ferdinand Westdahl.	Completion of the supplementary survey of the San Francisco Peninsula. (See also Section XI.)
	6	Force of gravity and magnetic observations.	R. A. Marr, acting assistant; A. D. Schindler, acting aid.	Determinations of the force of gravity and of relative magnetic intensity at San Francisco, Cal., in connection with similar observations at Point Barrow, Alaska.
	7	Force of gravity	Edwin Smith, assistant; Prof. H. S. Prichett.	Determinations of the force of gravity at San Francisco in connection with similar determinations at the Transit of Venus station in New Zealand, and at stations in Australia and eastern Asia.
	8	Tidal observations	E. Gray	Tidal observations, with self-registering tide-gauge, continued at Saucelito, near San Francisco Bay entrance.
	9	Triangulation	George Davidson, assistant; E. F. Dickins, assistant; J. F. Pratt, subassistant; C. B. Hill.	Occupation of stations of the primary triangulation north of San Francisco Bay. (See also Section XVI.)
	10	Hydrography	Lieut. W. T. Swinburne, U. S. N., assistant; Lieuts. J. B. Milton and W. P. Elliott, U. S. N.; Master F. H. Lefavor, U. S. N.	Continuation of hydrographic survey in the vicinity of Point Arena, Cal.
	11	Hydrography	Lieut. E. D. Taussig, U. S. N., assistant.	Hydrographic survey in the vicinity of Mendocino City, Cal.
	12	Triangulation	A. F. Rodgers, assistant; Stehman Forney, assistant.	Continuation of the primary triangulation of the north coast of California.
SECTION XI.				
Oregon and Washington Territory, including coast, interior bays, ports, and rivers.	No. 1	Triangulation and and topography.	L. A. Sengteller, assistant	Survey of the Umpquah River, Oreg. (See also Section X.)
	2	Triangulation and topography.	Cleveland Rockwell, assistant	Continuation of the Survey of Columbia River and tributaries.
	3	Hydrography	Lieut. T. Dix Bolles, U. S. N., assistant; Ensign J. N. Jordan, U. S. N.	Hydrographic surveys of Gray's Harbor, and in the Straits of Fuca and Admiralty Inlet, Wash. Ter.
	4	Triangulation	J. J. Gilbert, assistant	Triangulation of Hood's Canal, Wash. Ter. (See also Section X.)
SECTION XII.				
Alaska, including the coast and the Aleutian Islands.	No. 1	Hydrographic reconnaissance and magnetic observations.	Lieut. H. E. Nichols, U. S. N., assistant; Ensigns F. W. Coffin, C. F. Pond, S. E. Woodworth, and W. V. Bronaugh, U. S. N.; Fremont Morse, aid.	Continuation of the hydrographic reconnaissance of shore line and harbors of southeastern Alaska.
	2	Tidal observations	W. J. Fisher	Tidal observations continued with self-registering tide-gauge at Saint Paul, Kadiak Island, Alaska.
	3	Force of gravity and magnetic observations.	R. A. Marr, acting assistant; A. D. Schindler, acting aid.	Determinations of the force of gravity, and relative magnetic intensity at Point Barrow, Alaska. (See also Section X.)
	4	Longitude	Winslow Upton, Signal Service; F. Westdahl and C. B. Hill, Coast and Geodetic Survey.	Longitude of Point Barrow, Alaska.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION XIII.				
Kentucky and Tennessee..	No. 1	Telegraphic longitudes.	George W. Dean, assistant; Francis H. Parsons, subassistant; Carlisle Terry, jr., aid; J. W. G. Atkins, acting aid.	Occupation of the longitude station at Louisville, Ky., for the determination of the longitudes of additional stations in Kentucky by exchanges of telegraphic signals. Determinations of the latitudes of these stations. (See also Sections XIV and XV.)
	2	Geodetic..........	Carl Schenck, acting assistant....	Reconnaissance for the extension of the triangulation of the State of Kentucky.
	3	Geodetic..........	Prof. A. H. Buchanan, acting assistant.	Occupation of stations in continuation of the triangulation of the State of Tennessee.
SECTION XIV.				
Ohio, Indiana, Illinois, Michigan, and Wisconsin.	No. 1	Reconnaissance...	A. T. Mosman, assistant; W. B. Fairfield, extra observer.	Reconnaissance for the primary triangulation near the thirty-ninth parallel extended from West Virginia into Ohio and Kentucky. (See also Sections II and III.)
	2	Geodetic..........	Prof. R. S. Devol, acting assistant.	Occupation of stations in continuation of the triangulation of the State of Ohio.
	3	Geodetic..........	Prof. J. L. Campbell, acting assistant.	Reconnaissance for the extension of the triangulation of the State of Indiana.
	4	Geographical positions.	Francis H. Parsons, subassistant.	Determinations of the latitude and longitude of stations in Indiana. (See also Sections III, VIII, and XIII.)
	5	Geodesic leveling.	Andrew Braid, assistant..........	Transcontinental line of geodesic leveling extended from Mitchell, Ind., to Saint Louis, Mo. (See also Section XV.)
	6	Triangulation	G. A. Fairfield, assistant; J. B. Weir, subassistant; Carlisle Terry, jr., aid (part of season); T. P. Borden, aid (part of season).	Continuation to the eastward of the primary triangulation in Illinois, near the thirty-ninth parallel.
	7	Geodetic..........	Prof. J. E. Davies, acting assistant.	Occupation of stations in continuation of the triangulation of the State of Wisconsin.
SECTION XV.				
Missouri, Kansas, Iowa, Nebraska, Minnesota, and Dakota.	No. 1	Telegraphic longitudes, and determinations of latitudes.	George W. Dean, assistant; C. H. Sinclair, subassistant; F. H. Parsons, subassistant; Carlisle Terry, jr., aid.	Occupation of the longitude station in Saint Louis, Mo., for the determination of the longitudes of points in Arkansas, Missouri, Nebraska, Kentucky, Indiana, and Illinois, by exchanges of telegraphic signals. Determinations of the latitudes of these points. (See also Sections XIII and XIV.)
	2	Triangulation.....	F. D. Granger, assistant; J. E. McGrath, aid; J. A. Johnson.	Continuation to the westward of the primary triangulation in Missouri near the thirty-ninth parallel.
	3	Geodesic leveling.	Andrew Braid, assistant; J. B. Weir, subassistant.	Transcontinental line of geodesic leveling carried westward from Saint Louis towards Kansas City, Mo. (See also Section XIV.)
SECTION XVI.				
Nevada, Utah, Colorado, Arizona, and New Mexico.	No. 1	Triangulation.....	William Eimbeck, assistant; R. A. Marr, aid.	Primary triangulation in Nevada near the thirty-ninth parallel extended eastward.
	2	Reconnaissance...	F. W. Perkins, assistant; G. F. Bird, aid.	Reconnaissance for the extension eastward of the primary triangulation near the thirty-ninth parallel in Colorado. (See also Section VIII.)
	3	Observations of the Transit of Venus.	George Davidson, assistant; James S. Lawson, assistant; J. F. Pratt, subassistant; D. C. Chapman and T. S. Tappan, photographers.	Observation of the Transit of Venus at Cerro Roblero, near Fort Selden, N. Mex. (See also Section X.)
SECTION XVII.				
Idaho, Wyoming, and Montana Territory.	No. 1	Verification of boundary.	B. A. Colonna, assistant; T. P. Borden, aid; C. D. Gedney.	Completion of the work of verification of the northern boundary of Wyoming Territory. (See also Section VI.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SPECIAL OPERATIONS.				
Auckland, New Zealand, and stations in Eastern Asia.	......	Observations of the Transit of Venus and determinations of the force of gravity.	Edwin Smith, assistant; Prof. H. S. Prichett.	Observations of the Transit of Venus at Auckland, New Zealand. Also determinations of the force of gravity at the Transit of Venus station, and at stations in New South Wales, British India, and Japan.
Caroline Island, South Pacific Ocean.	....	Observations of the Total Solar Eclipse and determinations of the force of gravity.	E D. Preston, aid	Observations in connection with those made at Caroline Island, South Pacific Ocean, of the Total Eclipse of the Sun, May 6, 1883. Also determinations of the force of gravity at the Eclipse station, and at stations in the Sandwich Islands, and in San Francisco, Cal.
Honolulu, Sandwich Islands.	....	Tidal observations.	....	Tidal record from the self-registering tide-gauge established at Honolulu, Sandwich Islands.

APPENDIX No. 2.

Statistics of field and office work of the United States Coast and Geodetic Survey for the year ending June 30, 1883.

	Total to June 30, 1882.	Total during year.	Total to June 30, 1883.
RECONNAISSANCE.			
Area in square statute miles	278, 250	8, 500	286, 750
Parties, number of	....	3	....
BASE-LINES.			
Primary, number of	14	0	14
Subsidiary, number of	124	3	127
Primary, length of, in statute miles	90	0	90
Subsidiary, length of, in statute miles	301	125	426
TRIANGULATION.			
Area in square statute miles	175, 197	15, 500	190, 697
Stations occupied for horizontal measures, number of	10, 328	194	10, 522
Geographical positions determined, number of	19, 570	488	20, 058
Stations occupied for vertical measures, number of	639	17	656
Elevations determined trigonometrically, number of	1, 680	39	1, 719
Elevations determined by spirit-leveling, number of bench-marks	1, 766	331	2, 097
Lines of spirit-leveling, length of, in statute miles	2, 162	324	2, 486
Triangulation and leveling parties, number of	....	27	....
ASTRONOMICAL WORK.			
Azimuth stations, number of	175	8	183
Latitude stations, number of	279	17	296
Longitude stations (new), telegraphic, number of	105	10	115
Longitude stations, chronometric or lunar, number of	110	0	110
Astronomical parties, number of	....	8	....
MAGNETIC WORK.			
Stations occupied, number of new	651	13	664
Permanent magnetic stations, number of	....	2	....
Magnetic parties, number of	....	5	....
TOPOGRAPHY.			
Area surveyed, in square statute miles	28, 255	428	28, 683
Length of general coast, in statute miles	6, 368	121	6, 489
Length of shore-line, in statute miles, including rivers, creeks, and ponds	80, 878	1, 700	82, 578
Length of roads, in statute miles	41, 106	830	41, 936
Topographical parties, number of	....	17	....
HYDROGRAPHY.			
Parties, number of	....	26	....
Number of miles (geographical) run while sounding	345, 763	10, 806	356, 569
Area sounded, in square geographical miles	87, 390	3, 314	90, 704
Miles run, additional to outside or deep-sea sounding	73, 180	1, 568	74, 748
Number of soundings	15, 812, 638	390, 764	16, 203, 402
Deep-sea soundings	....	3, 194	....
Deep-sea temperature observations	....	3, 035	....
Tidal stations, permanent, number of	255	4	259
Tidal stations, temporary, number of	1, 842	68	1, 910
Tidal parties, number of	....	27	....
Current stations, number of	572	15	587

APPENDIX No. 2—Continued.

	Total to June 30, 1882.	Total during year.	Total to June 30, 1883.
HYDROGRAPHY—Continued.			
Current parties, number of	....	1	....
Specimens of bottom, number of	11,784	308	12,092
RECORDS.			
Triangulation, originals, number of volumes	3,738	272	4,010
Astronomical observations, originals, number of volumes	1,589	62	1,651
Magnetic observations, originals, number of volumes	525	11	536
Duplicates of above, number of volumes	3,879	321	4,200
Computations, number of volumes	3,420	159	3,579
Hydrographic soundings and angles, originals, number of volumes	8,450	257	8,707
Hydrographic soundings and angles, duplicates, number of volumes	1,508	191	1,699
Tidal and current observations, originals, number of volumes	3,377	85	3,462
Tidal and current observations, duplicates, number of volumes	2,186	76	2,262
Sheets from self-registering tide-gauges, number of	2,853	71	2,924
Tidal reductions, number of volumes	1,850	30	1,880
MAPS AND CHARTS.			
Topographical maps, originals	1,625	17	1,642
Hydrographic charts, originals	1,671	50	1,721
Reductions from original sheets	913	14	927
Total number of manuscript maps and charts	2,674	14	2,688
Number of sketches made in field and office	3,164	42	3,206
ENGRAVING AND PRINTING.			
Engraved plates of finished charts, number of	257	10	267
Engraved plates of preliminary charts, sketches, and diagrams for the Coast and Geodetic Survey reports, number of	632	7	639
Electrotype plates made	1,624	39	1,663
Finished charts published	364	27	391
Engraved plates of Coast Pilot charts	61	1	62
Engraved plates of Coast Pilot views	78	....	78
Printed sheets of maps and charts distributed	501,193	32,012	533,205
Printed sheets of maps and charts deposited with sale agents	195,450	16,612	212,062

APPENDIX No. 3.

Information furnished from the office of the Coast and Geodetic Survey in reply to special calls during the year ending June 30, 1883.

Date.		Name.	Data furnished.
1882.			
July	2	Hon. J. K. Upton, Washington	Compiled map of the Atlantic coast of Florida from Saint Andrew's Sound to Biscayne Bay, and map of Peninsula of Florida.
	5	J. K. Hines and M. de K. Smith, attorneys, Chestertown, Md.	As to secular change of magnetic declination since 1728.
	5	G. Edmunds, Harrisville, N. J	Height of Monadnock Mountain and bearings to other stations.
	5	J. O. Caldwell, Corpus Christi, Tex	Geographical positions vicinity of Corpus Christi.
	6	F. Sylvester, Pleasant Plains, Staten Island, N. Y	Magnetic declination at New York.
	6	Mr. W. R. Hutton, consulting engineer, New York	Topographical and hydrographic surveys of Hudson River from Mount Saint Vincent to Piermont.
	7	F. Sylvester, Maspeth, Long Island	Bench-marks at Keyport for setting a dock.
	12	Richard Lamb, city engineer, Norfolk, Va	Tides in the Bay of Fundy and on the Atlantic coast.
	14	J. C. Hoadley, Boston, Mass	Position of Lawrence, Mass.
	17	C. A. Ashburner, Geological Survey, Pennsylvania	Geodetic information in regard to stations Whitehorse, Port Clinton, and Bake Oven, Pa.
	18	Hon. Eugene Hale, of Maine	Topographical survey of part of Mount Desert Island.
	18	Hon. Samuel F. Barr, of Pennsylvania	Topographical survey of Mount Desert Island from Northeast Harbor to Seal Cove, Me.
	18	Commander W. T. Truxtun, U. S. N	Hydrographic survey of Elizabeth River from Fort Norfolk to Tanner's Creek, Va., made in 1882.
	24	Mr. W. L. Creiglar, Washington County, Fla	Unfinished proof of coast chart No. 85 from Saint Andrews Bay to Choctawhatchee Inlet, Fla., brought up by hand.
	24	Mr. E. H. Roberts, Santa Rosa County, Fla	Do.
	28	J. P. Genthon, S. Penn. R. R. Co., 57 Broadway, New York.	Geographical positions of Harrisburg, Wheeling, Washington, Alleghany, and Pittsburg.
Aug.	9	Director of the United States Geological Survey	Geographical positions in the region of the Blue Ridge, in Virginia and North Carolina.
	11	..... do	Geographical positions in Missouri.
	12	M. J. Campbell, Sibley, Iowa	Geographical positions, altitude, and magnetic declination of Sibley.
	15	Mr. James Albert Clark, Washington, D. C	Topographical survey of the Virginia shore of the Potomac River from Rosier's Creek to Monroe's Creek, made in 1862.
	17	Mr. S. K. Abbott, 93 Federal street, Boston, Mass	Topographical survey of Petit Manan Point, 1880, and Trafton's Island, 1881.
	21	J. P. Bogart, Shell Fish Commissioner, New Haven, Conn	Positions of Branford Church, Falkner's Id. L. H. and N. Killingsworth, and distance and azimuth between the latter objects.
	22	Chief of Engineers, U. S. A	Latitude and longitude of a number of astronomical stations.
	24	Mississippi River Commission	Results of spirit-levels on the Mississippi River between Greenville, Miss., and Carrollton, La., and descriptions of bench-marks between Lake Providence, La., and Fort Adams, Miss.
	24	New York Evening Telegram	Map of Coney Island issued in July, 1879, showing comparisons of the surveys between 1840 and 1881, with four profiles from the surveys of 1855, 1878, and 1881.
	26	Verplanck Colvin, superintendent Adirondack Survey	Geographical positions of Bigelow, Mount Mansfield, Dannemora, and Rand.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1882.			
Aug.	26	Prof. George H. Cook, State Geologist of New Jersey	Copies of the plane-table work, coast of New Jersey, from Brigantine Inlet northward to near Tom's River, and of the survey of 1839 of Long Beach, south of Barnegat Inlet, New Jersey.
	28	Mr. Morgan Hand, deputy clerk Cape May County	Topography of Cape May, N. J., survey of 1842, with shore-line of survey of 1879.
	28	Peter C. Hains, major of Engineers, Washington, D. C	Information relating to self-registering tide-gauges, and the makers of them.
	29	Prof. George H. Cook, State Geologist of New Jersey	Topography of the coast of New Jersey, Turtle Gut Inlet to Leaming's Beach, 1880 and 1881.
	29	C. C. Perkins, office City Surveyor, Boston	Description of old station Powderhorn.
	31	Prof. A. W. Phillips, Yale College, New Haven, Conn	Special tables for predicting tides for New Haven and several other places in Connecticut.
Sept.	4	General John Westcott, president Coast Line Canal and Transportation Company.	Hydrographic surveys of the Florida passage from Elbow Creek to Indian River Inlet, made in 1878 to 1881–1882.
	5	General H. G. Wright, chief of engineers	Hydrographic survey of Norwalk Harbor, Conn.
	5	......do	Hydrographic survey of Black Rock Harbor, Conn.
	5	......do	Hydrographic survey of Stamford Harbor, Conn.
	5	......do	Hydrographic survey of Southold Harbor, Suffolk County, N. Y.
	5	......do	Hydrographic survey of channel-ways of Peconic River and bays, Suffolk County, N. Y.
	5	......do	Hydrographic surveys of Stony Brook Harbor, Suffolk County, N. Y.
	6	J. G. Bramley, Saybrook, Conn	Description of several triangulation stations, northern shore of Long Island Sound.
	8	G. E. Waring, engineer, Newport, R. I	Computation of distances and azimuth of two points by latitude and longitude.
	16	General M. C. Meigs, United States Army	Rise and fall of tide at Washington, D. C.
	21	Captain J. H. Merryman, United States Revenue Marine	Topography of the coast of New Jersey, Whale Pond to Shark River.
	21	Mr. S. T. Abbott, United States civil engineer	Hydrographic survey of Quantico Creek, Va.
	21	......do	Hydrographic survey of Piscataway Creek, Md.
	21	......do	Hydrographic survey of Chickamuxen Creek, Md.
	21	......do	Hydrographic survey of Port Tobacco Creek, Md.
	21	......do	Hydrographic survey of Great Wicomico River, Md.
	21	......do	Hydrographic survey of Hull's Creek, Va.
	21	......do	Hydrographic survey of Piankatank River, Va.
	25	H. G. Brewer, Brighton P. O., Md	Magnetic declination at Brighton.
	25	G. E. Waring, Newport, R. I	Geographical position of Nashua, N. H.
	28	E. E. Glaskin & Co., 39 Broadway, New York City	Topographic and hydrographic survey of Deadman's Bay, west coast of Florida.
Oct.	2	Census Bureau	Table of factors of value of one minute of arc for various latitudes on the earth's surface, expressed in statute miles.
	7	Prof. J. R. Eastman, United States Naval Observatory	Geographical positions, triangulation of Cedar Keys, Fla., with description of stations.
	9	Commander W. P. Sampson, U. S. N	Chart of magnetic declination in New Mexico for 1882–1883.
	12	Widdifield & Co., opticians, Boston, Mass	Geographical positions and description of stations Mount Ascutney, of the village of Windsor, Vt.
	14	Prof. J. Ficklin, Glasgow Observatory, Mo	Results of star places and star factors in connection with latitude determination.
	17	Dr. B. L. Brigham, Franklin, Pa	Information about the position of the line of no magnetic declination.
	19	O. Stone, Leander McCormick Observatory, University of Virginia.	Astronomical position of observatory.
	19	Jed. Hotchkiss, Staunton, Va	Geographical positions, astronomical and geodetic, for Hotchkiss' Map of Virginia and West Virginia.
	20	Lieutenant F. W. Symons, United States Engineers	Heights in Washington Territory and Oregon.
	20	Dillon & Swayne, attorneys, New York City	Information relating to the tides in New York Harbor.
	23	Prof. O. H. Landreth, Vanderbilt University, Nashville, Tenn.	Geographical positions of C and G. S. astronomical station in Nashville, and information respecting local deflections of the vertical.
	23	C. H. Haswell, civil engineer, New York	Several geographical positions determined by the United States Coast and Geodetic Survey.
	23	Mississippi River Commission, Lieut. S. S. Leach, secretary.	Heights and descriptions of two bench-marks near Fort Adams.
	25	W. Watson, C. E., Pittsfield, Massachusetts	Heights of stations in western Massachusetts and pamphlets on magnetic declination in Massachusetts.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1882.			
Oct.	27	Mississippi River Commission	Geographical positions of the Mississippi River between Natchez and Donaldsonville.
	28	Mississippi River Commission	Elevation of several bench-marks.
	29	V. Calvin, superintendent Adirondack Survey, N. Y	Description of Coast and Geodetic Survey stations, vicinity of Lake Champlain.
	31	Col. John Newton, United States Corps of Engineers	Hydrographic survey of Stony Point Bay and Peekskill Harbor, Hudson River, N. Y.
Nov.	7	Lieutenant Smith S. Leach, secretary Mississippi River Commission, Saint Louis.	Two printed reports on tidal discussions.
	11	Mississippi River Commission	Description of trigonometrical stations on the Mississippi River, between Vicksburg and Natchez.
	13	Commander Henry H. Gorringe, United States Navy	Topographical and hydrographic survey of Arthur Kill, vicinity of Rossville, Staten Island, N. Y.
	14	Mr. William H. Doolittle, Washington, D. C	Area, length, and width of Salter's Island, near entrance to Kennebec River, Me.
	14	United States Census Bureau	Geographical positions of a number of towns.
	16	Prof. N. S. Shaler, Cambridge, Mass	Topographical survey of part of the island of Rhode Island, 1870.
	17	C. P. E. Burgwyn, engineer, James River Improvement	Results of Coast Survey tidal observations at Rockett's wharf in 1852.
	18	H. Vance, assistant engineer to Major Suter, United States Engineers.	Geographical position of Tavern Rock and Cedar, Mo.
	20	Mississippi River Commission	Description of trigonometrical stations on the Mississippi River between Natchez and Fort Adams.
	21	P. H. Baermann, assistant superintendent Water Commissioner's office, Troy, N. Y.	Information relating to self-registering tide-gauge.
	22	Prof. R. W. Wilson, astronomer Yale College Observatory, New Haven, Conn.	Geographical position of observatory, azimuths and distances.
	22	H. E. Magruder, Keswick Depot, Va	Magnetic declination at Charlottesville, Va.
	22	Mr. Calvin W. Pool, Rockport, Mass	Hydrography and shore line of Cape Ann, Mass., from Andrews on to Cape Hodge.
	23	C. H. Bunce, city engineer, Hartford, Conn	Geographical positions in Hartford for use of the German Transit of Venus party.
	24	F. L. Pope, solicitor of patents, 32 Park Place, New York.	Geographical position of New York City Hall.
	27	City of Portland, Me	Topographical survey of the Hog Islands, Casco Bay, Me.
	28	Advisory Board for Norfolk Harbor	Hydrographic surveys from above the Navy-Yard to Norfolk and Western Railroad bridge.
Dec.	1	J. P. Bogart, engineer, New Haven, Conn	Geographical position of Branford Congregational Church.
	1	C. H. Rockwell, Tarrytown, N. Y	Geographical position of Tarrytown school-house.
	1	Mr. George C. Burgess, assessor, Portland, Me	Topographical survey of Peake's Island, Portland Harbor, Me.
	2	H. Gannett, chief geographer United States Geological Survey.	Distance triangulation stations Benn-Poore, N. C.
	2	J. Ficklin, University of the State of Missouri, Columbia, Mo.	Proper motion of Stars 1683 and 1855 of Coast Survey catalogue.
	5	Lieutenant Smith S. Leach, secretary Mississippi River Commission.	Six rolls tide-gauge paper sent to W. G. Price, Ocean Springs, Miss.
	6	E. S. Martin, Wilmington, N. C	Position of astronomical station at Wilmington, and description of same.
	11	J. T. Sprague, for Major Hains, Potomac Flats Survey	Information relating to self-registering tide-gauges.
	22	W. A. Allen, engineer of the Maine Central Railroad, Portland.	Bench-marks on the Coast of Maine.
	26	J. S. Leach, Scotland post-office, Mass	Formula for secular variation of the magnetic declination in Plymouth County, Mass.
	28	Mr. S. K. Abbott, 93 Federal street, Boston, Mass	Area, in acres, of Petit Manan Point and Trafton's Island, Me.
1883.			
Jan.	2	Xenos Clark, Boston, Mass	Information relating to the new tide-predicting machine.
	3	Dunham & Payne, Cleveland, Ohio	List of heights above sea-level in Pennsylvania.
	6	Mr. T. B. Brooks, Newburgh, N. Y	Shore-line survey of the shores of the Hudson River, Stony Point to West Point, from surveys between 1854 and 1882.
	10	V. Colvin, superintendent Adirondack Survey	Geographical positions to the east and south of the Adirondacks.
	10	H. S. Duval, State Engineer, Jacksonville, Fla	Notes on magnetic declination at mouth of the Saint John's River and geographical positions of light-houses.
	10	W. Evans, Moorestown, N. J	Geographical position of Moorestown church.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1883.			
Jan.	11	War Department, Adjutant-General's Office	Tracing of Narrows, New York Harbor, giving distances between Fort Tompkins light-house, Fort Hamilton flag-staff, and upper Quarantine.
	16	Mr. J. Reed, Chincoteague, Accomac County, Va	Hydrography of Chincoteague Bay, vicinity of Chincoteague Island, 1880.
	17	Geo. E. Waring, expert and special agent Tenth Census.	Autographic map of Newport and vicinity, 1872, scale 1-10000.
	18	C. C. Perkins, office city surveyor, Boston, Mass	Description of station Prospect Hill.
	26	F. E. Idley, Consolidated Electric Light Company, N.Y.	Horizontal magnetic intensity, New York and Brooklyn.
	29	W. H. Richards, New London Water Works	Information on magnetic declination at New London.
	30	Cornell University	Statement of length of 4-meter base bars A and B
	30	F. B. Brooks, Newburgh, N. Y.	Magnetic declination on the Hudson River, middle and lower part.
Feb.	1	J. P. Bogart, engineer Shell Fish Commission, New Haven, Conn.	Geographical position of Eaton Neck light-house.
	3	Prof. W. P. Trowbridge, School of Mines, Columbia College, N. Y.	Compiled topographical map, bordering Hell Gate, Harlem and East Rivers.
	5	R. E. Peary, civil engineer United States Navy, Key West, Fla.	Hydrographic survey part of Key West Harbor, 1882.
	6	T. B. Brooks, Newburgh, N. Y	Geographical positions, vicinity of Bear Mountain, Crow's Nest, and Newburgh, with descriptions of trigonometrical stations.
	10	Prof. C. F. Emerson, Dartmouth College, Hanover, N. H.	Magnetic horizontal intensity at Dartmouth College Observatory.
	10	Hon. D. Ermentrout	Geographical positions in Berks County, Pa.
	10	W. C. Kerr, State Geologist of N. C	Position of a number of prominent mountain peaks in North Carolina.
	10	C. C. Royce, Bureau of Ethnology, Smithsonian Institution.	Tides in Saint Mary's River, Fla.
	12	H. Best & Son, Dayton, Ohio	Difference of longitude, Dayton and Columbus, Ohio.
	16	W. C. Kerr, State Geologist of N. C	Height of Mitchell's Peak, N. C.
	19	Messrs. Whitman & Breck, civil engineers and surveyors, Boston, Mass.	Topographical survey of part of Cape Ann, vicinity of Gloucester, Mass., 1851.
	23	O. S. Wilson, New York State Survey, Albany	Geodetic data with reference to stations Helderberg and Rafinesque.
	24	J. K. Rhees, Columbia College, N. Y.	Magnetic declination at Coney Island, Long Island, at two epochs.
	24	General Wm. B. Hazen, Chief Signal-Officer	Magnetic chart of Smith Sound, Kennedy and Robeson Channels, North Greenland, 1882.
	27	George E. Waring, jr., consulting engineer, &c	Tracing of Thames River, vicinity of Norwich, Conn.
Mar.	1	Lieutenant-Commander C. H. Davis, United States Navy.	Description of Coast Survey astronomical station at Galveston Bay, Tex., and telegraphic longitude of same.
	1	Prof. J. R. Eastman, United States Naval Observatory	Information respecting Coast Survey astronomical station, Cedar Keys, Fla.
	3	Prof. Alexander Agassiz	Preliminary plotting of the steamer Blake's deep-sea soundings, season of 1882-'83, with a profile.
	5	T. J. Long, engineer Department of Docks, New York	The average tidal curve at Sandy Hook.
	6	H. J. Lovick, surveyor, New Berne, N. C	Magnetic declination from 1760 to present time.
	6	Publisher of "Science"	Section of deep-sea soundings by steamer Blake, scale 1-5000000, with 25 profiles.
	7	H. T. Bradford, surveyor, Lebanon, Ohio	Information about terrestrial magnetism.
	9	Mississippi River Commission	Description of trigonometrical stations between Baton Rouge and Donaldsonville.
	9	F. W. Schwartz, assistant engineer, United States Engineer office, New Orleans.	Results of spirit levels, Greenville to Carrollton.
	12	J. P. Bogart, New Haven, Conn	Annual variation of the magnetic declination at New Haven.
	12	Mr. W. W. Coe, chief engineer Norfolk and Western Railroad.	Topographical survey of the eastern shore of Elizabeth River from Lambert's Creek to Tanner's Creek.
	13	Lieutenant Smith S. Leach, secretary of Mississippi River Commission.	Three blank tide-rolls sent at his request to G. B. Fewell, gauge-keeper at Biloxi, Miss.
	14	Commander flagship Tennessee	Hydrography of Norfolk Harbor, from Craney Island to Naval Hospital.
	14	Prof. C. Abbe, United States Signal Corps	Geographical positions of 98 points.
	19	J. B. Hoeing, Kentucky Geological Survey	Position of astronomical station at Goodson, Va. (Bristol, Tenn).
	20	J. P. Bogart, Shell-Fish Commission, Connecticut	Geographical position of a spire in West Haven.
	21	J. P. Little, surveyor, Belzoin, Miss	Advice respecting magnetic chart.
	23	M. Sharpless, Philadelphia	Information respecting local deflection of vertical at station yard.
	26	J. P. Bogart, engineer, Shell-Fish Commission	Two projections, scale 1-20000, of the Connecticut shore, from near Rye Point eastward to Pine Creek Point, with shore line.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1883.			
Mar.	27	Lieut. Col. George H. Elliot, Corps of Engineers	Topographical and hydrographic surveys of the Providence River, from Field's Point to Conimicut Point light-house, R. I.
	29	E. W. Little, Ocean Grove, N. J	Relative to the depth of the Atlantic and Pacific Oceans.
	29	H. E. Rosenstock, civil engineer and surveyor, Montgomery, Ala.	Information respecting magnetic declination at Mobile and Montgomery.
	29	J. P. Bogart, engineer, Shell-Fish Commission, Connecticut	Geographical position of Stratford Beacon.
	30	Major P. C. Hains, U. S. Engineers, Washington, D. C	Relating to supply of blank rolls for a tide-gauge.
Apr.	2	Mr. W. W. Coe, chief engineer Norfolk and Western Railroad.	Hydrographic survey of the Elizabeth River, between Lambert's and Tanner's Creeks, 1882.
	2	Mr. W. W. Huck, secretary Louisiana Telephone Company	Shore-line of the Mississippi River, vicinity of Baton Rouge, 1880, scale 1-10000.
	6	J. T. Gardner, superintendent New York State Survey, Albany.	Sixty-five geographical positions and descriptions of stations on Staten Island, N. Y.
	7	V. Colvin, superintendent Adirondack Survey	Geographical positions of stations connecting the triangulation of Lake Champlain with the main triangulation.
	7	James L. Lusk, first lieutenant Engineers, Apalachicola, Fla.	Bench-marks for several places in Florida.
	9	G. H. Cook, director Geological Survey of New Jersey	Descriptions of six trigonometrical stations in New Jersey.
	9	W. Sharswood, Philadelphia	Height of Moore's Knob, N. C.
	11	J. T. Gardner, superintendent New York State Survey	Geographical position of Princess Bay light-house.
	13	Mr. L. B. Russell, county surveyor, Refugio City, Tex	Unfinished proof of coast chart No. 109, Aransas Pass, Aransas and Copano Bays, Tex., brought up by hand.
	14	Mr. Martin P. Gray, Salem, N. Y	Topographical survey of the Pennsylvania shore of the Delaware River, vicinity of Hog Island, 1842.
	16	Commander George W. Coffin, light-house inspector	Hydrographic survey, Western Coast, between Point Conception and Point Arguello, Cal.
	16	Prof. F. J. Child, Cambridge, Mass	Yearly highest rise of water at New Orleans during several years.
	18	Mr. Oscar Darling, civil engineer and surveyor, Huntington, L. I.	Topographical survey of the eastern side of Cold Spring Harbor, Long Island, N. Y., 1836.
	19	N. H. Hatton, engineer office, Harbor Board, Baltimore	Geographical positions of Havre de Grace light-house and Mauldin Station, with distance and azimuth.
	21	Mr. Thomas H. Abbott, pilot revenue steamer E. A. Stevens.	Unfinished proof of coast charts Nos. 42 and 43. Eastern and middle parts of Pamplico Sound brought up by hand.
	27	Mr. Oscar Darling, civil engineer and surveyor, Huntington, L. I.	Sketch of Cold Spring Harbor, L. I., showing triangulation stations, 1836.
	28	Engineer department, R. and H., Ottawa, Ontario	Difference of level New York, half-tide, and Albany, sill of canal, lock No. 1.
May	1	Mr. W. W. Coe, chief engineer Norfolk and Western Railroad.	Hydrography and topography of the James River, vicinity of City Point, $\frac{1}{10000}$, compiled from the surveys of 1852, 1875, and 1880.
	1	G. F. Baillairge, for Minister of Public Works, Ottawa, Ontario, Canada.	Mean low water at Governor's Island below that at Albany.
	4	Mr. Lavalette Wilson, civil engineer, Haverstraw, N. Y	Shore-line of the west side of the Hudson River, from Waldberg Landing to Caldwell's Landing, 1854–1864, and 1881.
	5	Director of the United States Geological Survey	Geographical positions of astronomically determined stations in the Appalachian Range, south of latitude 39°.
	5	Department of the Interior, General Land Office	Astronomical positions in Utah, Idaho, Oregon, and Washington Territory.
	7	Major James B. Roche, paymaster United States Army	Distances in statute and nautical miles from Pier 28, North River, to Newport and Fall River.
	11	L. Q. C. Lamar, United States Senate	Height and slope of Mississippi River, Gulf to Carrollton and Red River Landing.
	12	Commandant J. Perrier, Paris, France	Statistics of base-lines measured by the Coast and Geodetic Survey since 1879.
	12	W. Welch, lieut. United States Navy, Pensacola, Fla	Bench-marks at Pensacola, for the use of commission on navy-yards.
	12	Lieut. Wm. Welch, commanding Pensacola navy-yard	Description of bench-mark at Fort Pickens, Fla.
	12	Major James R. Roche, paymaster United States Army	Distance in nautical and statute miles between Boston and Provincetown, Mass.
	17	......do	Distance in nautical and statute miles between Baltimore and Tolchester Beach, Kent County, Md.
	19	Mr. Richard Wayne Parker, Newark, N. J	High and low water lines of Jersey City, from survey of 1837.
	23	E. P. Austin, Salt Lake City, Utah	A copy of the Atlantic Coast Tide Tables for 1884, sent to him for use on his Boston Almanac.
	23	C. H. Metcalf, Harvard University, Cambridge, Mass	A copy of Tide Tables for Atlantic Coast for 1884 sent to him.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1883.			
May	24	G. H. Cook, director of State Geological Survey, New Jersey.	Description of six trigonometrical stations, coast of New Jersey.
	24	J. B. Hoeing, Kentucky Geological Survey	Descriptions of some astronomical stations in Kentucky, Ohio, and Illinois.
	24	Mr. H. S. Crowell, Boston, Mass	Topographical survey of Buzzard's Bay, Bennet's Neck to Weweantic River, made in 1845.
	25	Maj. Chas. W. Raymond, Corps of Engineers, engineer first and second light-house districts.	Hydrographic survey of Burnt Coat Harbor and approaches, Blue Hill Bay, Me.
	26	Geo. Davidson, for lawyers in San Francisco	Tracings from Saucelito tidal curves from 16 to 21 of June, 1882, for use in a case about a lost ship.
	29	Maj. James R. Roche, paymaster United States Army	Distance in nautical and statute miles from New Bedford to Wood's Holl and Wood's Holl to Nantucket.
	29	Bureau of Navigation, Navy Department	Hydrographic projection, scale 1–5000, part of Beaufort River, S. C., south of Battery Creek; description of triangulation stations, hydrographic signals, and bench-mark.
	31	Prof. W. C. Kerr, North Carolina	Sketch showing deep-sea contours, Atlantic coast, from soundings taken by steamer Blake in 1880 and 1883, scale 1–5000000.
June	1	C. P. E. Burgwyn, engineer James River Improvement, Richmond, Va.	Description of trigonometrical station, "Capitol."
	2	Mr. J. N. Lyles, New York	Topographical survey of 1882 of Fisher's Island, Long Island Sound, N. Y., scale 1–10000.
	2	Mr. Theodore Overbeck, city surveyor of Gloucester, Mass.	Topographical survey of the western shore of Annisquam and Gloucester Harbors, Mass., 1851, scale 1–10000.
	7	Prof. Geo. H. Cook, State Geologist, New Jersey	Photographic copies of plane-table sheets of Absecon Inlet and head of Barnegat Bay, N. J.
	9	J. Clyde Power, engineer in charge Southern Maryland Railroad.	Topographical survey between Benning's Bridge and east corner stone of District of Columbia, 1865.
	9	J. S. Underhill, East Charleston, Vt	Secular variation in magnetic declination.
	11	Lieut. E. H. Moore, United States Naval Observatory	Longitude of Louisville and Paducah, Ky.
	11	W. C. Kerr, United States Geological Survey	Dimensions and information about conoidal reflectors for triangulation purposes.
	12	United States Light-House Board	Hydrographic resurvey of Croatan Sound, N. C., 1883.
	13	Mr. Geo. Eldridge, hydrographer	Hydrographic survey of Bass Harbor Bar, entrance to Blue Hill Bay, Me.
	14	United States Light-House Board	Hydrographic survey of Shagwong Reef, Block Island Sound, 1882.
	15	Prof. Geo. H. Cook, director of Geological Survey of New Jersey.	A number of geographical positions and triangulation data, coast of New Jersey and shore of Delaware Bay.
	18	Mr. H. S. Crowell, Boston, Mass	Topographical survey of east side of Buzzard's Bay from Bennet's Neck to Scraggy Neck, 1845.
	18	Col. Chas. E. Blunt, Corps of Engineers	Hydrographic survey of Wood Island Harbor off Saco River, Me., 1857.
	20	J. Fras. Le Baron, United States Engineer office, Jackville, Fla.	Bench-marks for several places on the Saint John's River and Saint George's Inlet for ship-canal surveys.
	21	Q. A. Gillmore, colonel of Engineers, United States Army	Geographical positions and descriptions of trigonometrical stations Savannah River between Bird Island and Tybee light-house.
	30	......do	Additional geographical positions on Savannah River below Bird Island.

APPENDIX No. 4.

REPORT OF THE ASSISTANT IN CHARGE OF OFFICE AND TOPOGRAPHY FOR THE YEAR ENDING JUNE 30, 1883.

WASHINGTON, *June* 30, 1883.

SIR: I submit herewith the reports of the chiefs of divisions of the office, showing the general character and extent of the work executed during the fiscal year ending June 30, 1883.

Beside the regular operations of the office, as given in appendices 2 and 3, and in these reports, I beg leave to refer to a few special results of the year, in the introduction of new instruments and of valuable additions to our facilities for prompt and superior out-turn of work.

TIDE-PREDICTING MACHINE.

The maxima and minima tide predicting machine, designed by Mr. William Ferrel, of this office, has been completed. A full description of this intricate labor-saving machine, with the necessary illustrations, will appear as Appendix No. 10 to your annual report for this year. I deem it only necessary to add here the fact that the principles on which it was constructed and the construction itself have been tested, and the results, compared with those deduced from the long processes of computation, have been satisfactory.

CLOSING LEVELS.

A new method of making and closing glass tube levels has been lately adopted, at the suggestion of G. N. Saegmuller, chief mechanician. The tubes are made with a short neck, as in the case of a vial, in which a closely fitting ground glass stopper is inserted, and then hermetically sealed by the usual simple means. The improvement consists in the facility with which the tube can be opened and cleared of impurities, or resupplied with ether in case of leakage.

CALENDER PRESS.

A large calender press or machine for finishing, by pressure, the surface of the largest charts issued by the Survey has been lately added to the printing-office. Independent of the improved appearance of the charts resulting from a pressure of nearly 250 tons, the paper is hardened and made tougher; the ink is more fixed, the distortion is more uniform, and hence sheets intended to be joined can be more correctly put together; and, it is believed, that further experiments and comparisons between the hand and machine made paper will result in the use of American paper, which would be a step favorable to economy.

ELECTROTYPING.

An increase in our capacity for electrotyping the engraved plates of the Survey has been long needed and discussed. Inquiries and personal examinations were made during the year, at some of the principal electrotype establishments in New York and elsewhere, in regard to the dynamo-electric machine, with a view to its substitution for the combination of Smee's and Walker's batteries now in use. The information obtained was not conclusive. The electrotyping of plates as

large as those of the Coast Survey had not even been attempted. As a last resort, we obtained from the navy-yard, Washington, through the courtesy of Lieutenant R. M. Cutts, U. S. N., the temporary use of a 10-inch Weston dynamo-electric machine, and employed as the motive power our two-horse Baxter steam-engine. The results were quite satisfactory on the small scale necessarily adopted. Nevertheless, taking into consideration the expense of the outlay and of additional labor, as well as the uncertainty in regard to large plates, it was deemed advisable to await further developments, and, in the mean time, to add two cells to our present batteries.

MAP OF THE UNITED STATES.

The accumulation of geographical data in the office of the Survey resulting from its own operations, as well as from other Government, State, and private surveys, would seem to suggest that, under the authority of Congress, initial steps should be taken toward the construction of a map of the United States.

Such a map, or rather atlas of maps, based on a scientific and unchangeable frame-work, executed on a scale appropriate to the extent of the country, and with all possible care and judgment in the selection and combination of the data, would constitute an official map of special value to the Government. Eventually, in the distant future, the different States will be in a condition to undertake a thorough survey of their respective areas, but until that time arrives, the official map will prove of acknowledged usefulness.

With a view to ascertain the practicability of the plan and of the probable time and expense to be incurred, experiments have been made both as regards the data and drawing, and so far with such promise of success that I do not hesitate to recommend that Congress should be requested to make a special appropriation for this particular work.

An estimate of the time and expense which will be required for the construction of the atlas, with a specimen of the style and scale proposed, will be presented in time for consideration at the coming session of Congress.

Besides the regular force permanently attached to and employed in the office, the following field officers were detailed by the Superintendent at different dates during the fiscal year for duty in the office of the Assistant in Charge, and were employed in the inking of topographical sheets, in bringing up the party records, and in the computations required before the field-work could be turned in to the office:

Assistant A. W. Longfellow, January 11 to February 14.
Assistant A. T. Mosman, January 1 to April 30.
Assistant W. H. Dennis, January 1 to June 30.
Assistant Charles Hosmer, January and February.
Assistant Andrew Braid, January and February.
Assistant Gershom Bradford, February 1 to June 30.
Assistant R. M. Bache, April 1 to June 30.
Assistant E. Ellicott, April 22 to June 30.
Assistant C. H. Boyd, May 20 to June 30.
Assistant F. W. Perkins, June.

It gives me sincere pleasure to refer to the zeal, efficiency, and promptness with which the chiefs of division have performed the various duties assigned to them.

In the office of the Assistant in Charge Assistant H. W. Blair served as his Assistant from July 1, 1882, to March 12, 1883, and Assistant Andrew Braid from March 12 to June 30, and I beg to acknowledge their valuable assistance and constant interest in the conduct of the office.

Mr. William B. French also deserves my thanks for the fidelity with which he has performed his clerical duties.

Yours, respectfully,

RICHD. D. CUTTS,
Assistant in Charge Office and Topography.

Prof. J. E. HILGARD,
Superintendent United States Coast and Geodetic Survey.

ANNUAL REPORT OF THE COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1883.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1883.

DEAR SIR: In conformity with regulations, I herewith respectfully submit the usual annual report of work done by the several computers during the year ending June 30, 1883.

The charge of the Computing Division has been continued with the undersigned, and no material change took place in its organization or management. With two exceptions the personnel is the same as in the closing month of last year. Mr. Alexander Ziwet was given the place vacated by the death of Dr. Rumpf, and the place of copyist or clerk, formerly held by Mr. C. W. Henderson was, after his decease (on December 24, 1882), filled first by Mr. J. W. G. Atkins temporarily, and afterwards permanently by Mr. P. R. Stansbury. There was also some temporary assistance given by persons assigned to the Computing Division when not on field duty.

Almost the whole of my spare time, after attending to the mere routine work of the Computing Division, was taken up by the discussion, report, and preparation for the press of certain geodetic and magnetic matter, viz: An account of the construction of a new compensation primary base, apparatus, including the determination of the length of the accompanying five-meter standard bars. Accompanying the description there are two large plates of illustrations and some small diagrams. This paper forms Appendix No. 7 of the annual report of the Survey for the fiscal year ending with June, 1882. In connection with this paper numerous comparisons were made under my direction by Messrs. D. C. Chapman, J. G. Porter, and A. Ziwet, of the six-meter and the five-meter plus one-meter standards, also of the two five-meter standards, and one of the five-meter standards with five joined meters. After the completion of this work in the comparing room the five-meter field standard, which had been used in the measure of the Yolo base, California, was returned to that State. The title of a second paper presented is "Computation and discussion of the length of the Yolo base, &c." The report made on the results of the transcontinental line of geodetic spirit-leveling, Parts I to V inclusive, or from Sandy Hook, N. J., to Saint Louis, Mo., forms Appendix No. 11 of the annual report for 1882. The discussion of the Davidson quadrilaterals (of the primary triangulation in California) was advanced as far as the state of the field-work permitted.

Respecting terrestrial magnetism, a fifth edition of the paper on the secular variation of the magnetic declination was brought out (illustrated with four plates). In this greatly enlarged edition about 837 declinations, observed at eighty-two stations, are fully discussed; this paper forms Appendix No. 12 in the annual report for 1882. The next paper brought out, and forming Appendix No. 13 of the same report, is entitled "Distribution of the magnetic declination in the United States at the epoch January, 1885, with three isogonic charts and one plate." This paper contains a table of all magnetic declinations taken in the country (as far as known to me) up to date—about 2,360—and reduced to the same epoch.

Magnetic observations were made on two days at the magnetic observatory in this city, and practical instructions were given under my direction by Subassistant Baylor to certain Signal Corps observers intended to participate in the magnetic work at the two polar stations.

The number of applications for scientific information from persons not connected with the Survey has been on the increase for some time. The ordinary office correspondence, the reporting of results of computations, the demands from the Drawing Division for geographical positions, of the Engraving Division for geodetic, astronomical, and magnetic data for the charts, and of the Hydrographic Division for description of geodetic stations, were promptly attended to. The registers of the *duplicate* records of the Survey were kept up to date.

The work, in detail, performed by each computer during the fiscal year is given below, together with a statement of the work done by those temporarily attached to the division.

Mr. Edward H. Courtenay computed part of the supplementary triangulation of Long Island Sound, 1882, also of 1873 to 1877, and fitted the old work of 1833 in this locality to the new data; computed the supplementary triangulation of Delaware Bay, 1882, and brought to the same uniform

data the older results of the triangulations of 1840–'41–'75–'77–'81; computed part of the triangulation near Tillamook Head, Oreg., 1875; computed the supplementary triangulation of Norfolk Harbor, Va., 1882; revised the results for magnetic intensity obtained by means of magnetometers No. 3 and No. 8; computed the absolute values for magnetic declination, dip, and intensity at Ooglaamie, Alaska, 1881–'82; arranged about fifty volumes of computations for the binder; had charge of the duplicate records; attended to the insertion of resulting geographical positions in the registers of this and of the Drawing Division; prepared geodetic data called for by field parties; and assisted in the preparation of the annual geodetic statistics.

Mr. Myrick H. Doolittle adjusted the triangulation of the east coast of Florida south of Saint Augustine, including the Indian River, of 1860–'61, of 1880–'81, and of 1882 and computed the traverse-work south of Indian River Inlet, 1882; computed the main triangulation in Western New York, intended to connect the triangulation of Lakes Champlain and Ontario, 1880–'81–'82; fitted the secondary triangulation of Lake Champlain of 1870–'71–'72 to the primary work; revised the triangulation connecting Jacksonville, Fla., with the sea-coast, 1854–'55; supplied a few additional positions of the old survey of Savannah River, and of Charleston Harbor and Saint Augustine, 1882, computed the triangulation at Sabine Pass, Tex., 1882; computed the base-line at Laguna Madre, Tex., 1882, and connected it with the triangulation; computed the traverse and geodetic work coast of Texas between Galveston and Sabine Pass, 1882; computed the triangulation of the coast of Oregon between Tillamook Head and Tillamook Bay, 1875, and of Tillamook Bay, 1866; assisted in the preparation of the annual geodetic statistics, and made progress with the reduction of the vertical angles of the primary triangulation of California.

Dr. Jermain G. Porter prepared the least-square abstract of resulting horizontal directions at primary stations Mount Como, Nev., 1879, Mount Grant, Nev., 1879, Carson Sink, Nev., 1880, Vaca, Cal., 1880, and Mount Tamalpais, Cal., 1882; revised the computations for latitude of Northwest Yolo base station; computed the magnetic observations of 1875, and of the northern boundary of Wyoming of 1882; assisted me in the reduction of the magnetic declinations to epoch 1885; made some miscellaneous magnetic computations and solved the normal equations containing the distribution of the declinations in Alaska; computed the spirit levels, Mount Diablo to Martinez East, Cal., 1880; assisted in the comparisons of the five- and six-meter standards (already referred to), and in the computations relating thereto; assisted me in the computation of the length of the Yolo Base, Cal., 1881; made the computation connecting the Yale College Observatory with the coast triangulation; supplied some miscellaneous geographical positions; prepared revised abstracts of resulting angles at all the stations of Pennsylvania and New Jersey, forming the so-called horseshoe triangulation, and established the first set of conditional equations for its adjustment.

Mr. Alexander S. Christie computed time and astronomical azimuth at the following stations: Northwest base Yolo, Cal., 1880; Monticello, Cal., 1880; Vaca, Cal., 1880; Venado, Tex., 1881; North base Laguna Madre, Tex., 1882, and made progress with station Mount Tamalpais, Cal., 1882; computed latitude and azimuth of station Ooglaamie, Alaska, 1881–'82; applied correction for changes of temperature to spirit-level results between Hagerstown, Md., and Athens, Ohio, and prepared abstract of results for the whole line between Sandy Hook, N. J., and Saint Louis, Mo., as printed in Appendix No. 11, report for 1882. Mr. Christie supplied the mean places of stars required by our astronomical parties.

Mr. Charles H. Kummell made the office computation of the following differences of longitudes as determined by the electric telegraph, viz: Nashville, Tenn., and Columbus, Ohio, 1877; Columbus, Ohio, and Washington, D. C., 1877; Columbus, Ohio, and Cambridge, Mass., 1871; Columbus, Ohio, and Cleveland, Ohio, 1871; Cleveland, Ohio, and Cambridge, Mass., 1871; Savannah, Ga., and Cedar Keys, Fla., 1874; Savannah, Ga., and Punta Rasa, Fla., 1874; Oakland, Ky., and Cambridge, Mass., 1871; Shelbyville, Ky., and Cambridge, Mass., 1871; Falmouth, Ky., and Cambridge, Mass., 1871; and commenced Baton Rouge, La., and Atlanta, Ga., 1880. Mr. Kummell also furnished some star places for field parties and revised vertical angles at Mount Diablo, Cal., 1880.

Mr. Henry Farquhar completed the computation for magnetic declination in California, Oregon, Washington Territory, and Idaho in 1881; computed the spirit levelings of Yolo Base, Cal., and of the line between Sandy Hook, N. J., and Hagerstown, Md.; revised the computations for two astronomical azimuths in Texas, 1881–'82, and computed the latitudes of Monticello, Cal., 1880, of

Carson Sink, Nev., 1880, and of Toiyabe Dome, Nev., 1880. He also computed the spirit-leveling between Flora, Ill., and Saint Louis, Mo., and made some progress with the continuation of this line to Etlah, Mo.; he also gave some attention to pendulum matters in charge of Assistant C. S. Peirce.

Mr. Alexander Ziwet was assigned to the Computing Division August 15, 1882, and has been engaged on the following work: The determination of the run of micrometers used at stations, Monticello, Cal., Vaca, Cal., and Como, Nev.; the computation of geographical positions (under Mr. Courtenay's special direction) coast of Connecticut, Long Island Sound, Delaware River and Bay, 1881-'82, and Norfolk Harbor, 1882; assisted in checking computations in connection with the length of Yolo base and other miscellaneous computations; plotted the position of the magnetic declinations for the new isogonic charts, and nearly completed the computation and adjustment of the triangulation connecting Suisun Bay, Cal., with Mount Diablo, 1880. He also assisted in the metric comparisons.

Mr. C. W. Henderson attended to the clerical duties of the Computing Division, chiefly furnishing copies of descriptions of stations and copying star-places for field parties, entering geographical positions in the registers of the Computing and Drawing Divisions, &c.

Mr. J. W. G. Atkins succeeded Mr. Henderson December 26, 1882, as copyist; he was ordered to field duty May 1, 1883.

Mr. V. J. Fagin acted temporarily as clerk to the Computing Division between May 10 and May 21, 1883.

Mr. P. R. Stansbury reported for clerical work in the Computing Division May 23, and continued to discharge this duty to the close of the year.

The following computers were temporarily assigned for duty in the Computing Division:

I. Winston between July 1 and July 18, and two days in August, 1882, was engaged on revision of magnetic computations.

C. B. Turnbull between July 7 and July 19, 1882, was engaged on miscellaneous copying.

Subassistant J. F. Pratt reported for duty January 11 and continued to May 25; was engaged on miscellaneous computations; computed geographical positions on the Saint John's River and other localities, and made satisfactory progress with the reduction of the spirit-levels between Mitchell, Ind., and Saint Louis, Mo.

Mr. J. C. Power was assigned to the Computing Division January 10, and continued to April 28, 1883; was mostly engaged in copying and some light computations.

CHAS. A. SCHOTT,
Assistant in Charge Computing Division.

R. D. CUTTS, Esq.,
Assistant in Charge of Office and Topography.

ANNUAL REPORT ON THE FIELD AND OFFICE WORK RELATING TO THE TIDES FOR THE YEAR ENDING JUNE 30, 1883.

TIDAL DIVISION, COAST AND GEODETIC SURVEY OFFICE,
June 30, 1883.

DEAR SIR: I respectfully submit this report on the work of the Tidal Division, of which I have been in charge during the year.

OBSERVATIONS.

Self-registering tide-gauges have been used at the following stations: North Haven, Me.; Providence, R. I.; Block Island, R. I.; New London, Conn.; Sandy Hook, N. J.; Saucelito, Cal.; Kadiak, Alaska; and Honolulu, Sandwich Islands. Nothing more has been learned about the observations at Mazatlan, Mexico. The Alaska Commercial Company was furnished some time ago with a box-gauge for temporary use at Copper Island, off the Asiatic coast of Bering Sea, but no return has yet been received.

So soon as a permanent tidal station shall be re-established on the Southern Atlantic coast of the United States, it would be advisable to establish a similar one on the island of Bermuda with a view to simultaneous observations for two or three years, in order to obtain data for a more full and general discussion of the tides.

To complete the data for a full investigation of the tides of the Gulf of Mexico, it will be necessary to occupy two or three new stations west of the Mississippi for a year each.

While at Long Branch last year I inspected the iron pier of the Ocean Pier Company there, and it seemed to me that a self-registering tide-gauge might be used on it successfully, by employing an iron pile for a float tube. As a permanent station the place appears to be free from some of the objectionable circumstances at Sandy Hook, and if, after a fair trial, the gauge should be found to work well, the Sandy Hook gauge could be stopped.

As full information has been given in the tidal notices under the different sections of the survey, of the observations made with self-registering gauges during the year, it is not necessary to give details here.

The following table gives the stations occupied by self-registering tide-gauges, and the da'es and period of the observations.

Section.	Name of station.	Name of observer.	Kind of gauge.	Permanent or temporary.	Time of occupation.		Total days.
					From—	To—	
I	North Haven, Me	J. G. Spaulding	Self-registering	Permanent	April 24, 1882	May 30, 1883	410
I	Providence, R. I	S. M. Gray	do	Temporary			
I	Block Island, R. I	J. M. Conley	do	do	July 27, 1882	July 1, 1883	339
II	New London, Conn	A. Koch	do	do	October 6, 1882	July 1, 1883	267
II	Sandy Hook, N. J	F. W. Shepheard	do	Permanent	June 1, 1882	July 1, 1883	395
X	Saucelito, Cal	E. Gray	do	do	June 1, 1882	July 1, 1883	395
XII	Kadiak, Alaska	W. J. Fisher	do	do	November 1, 1881	March 1, 1883	485
	Honolulu, S. I	W. D. Alexander	do	Temporary	December 28, 1881	July 20, 1882	204

A self-registering tide-gauge is now being repaired and fitted for use in the Delaware River below Philadelphia, in accordance with an arrangement with the United States Engineers, and there are two more in the office for which clocks are needed.

The tidal observations made by the hydrographic parties of the Coast Survey are inspected as soon as received, and mostly reduced in the Tidal Division. Notices of them will be found in the accounts of work done in the different sections of the Survey. They are generally made with a staff or a box-gauge, and are usually day observations only, and sometimes in disconnected groups. Where the diurnal inequality is large, this mode of working sometimes results in imperfectly reduced soundings. The only sure remedy is more continuous work kept up day and night.

OFFICE-WORK.

The observers using self-registering gauges are now generally required to tabulate the high and low waters and hourly readings from the curves before sending these to the office, and to send the tables and curves at different times to prevent losses by accidents. The observers in this way have become more skillful and careful, and the work in the office is considerably reduced. The observations received from the self registering gauges and hydrographic parties are reduced as soon as they can be conveniently, and the results used in prediction work, chart making, and for other purposes. The reductions and discussions that have been made enable the Division to furnish a large amount of information relating to tides to officers of the Survey, civil and United States Engineers, and others, the demand for which is rapidly increasing.

"Tide Tables" containing the predictions for the Atlantic and Pacific coasts of the United States for the year 1884 have been computed by the Tidal Division, and have been published, making the eighteenth year of the series.

The computers employed in this division in the course of the year were R. S. Avery, L. P. Shidy, M. Thomas, and C. B. Turnbull in the office, and J. Downes and J. G. Spaulding out of it.

Mr. Avery, being in charge of the division, inspected all tidal observations when received and prepared them for reduction, attended to the correspondence relating to tides, planned and supervised the work on tides and tide-gauges, prepared the predictions for printing and read the proofs, and computed when not otherwise engaged.

Mr. Shidy reduced many observations received from hydrographic parties, predicted for places where the diurnal inequality is large and some others, and aided in a large amount of miscellaneous work.

Miss Thomas worked on the simplest reductions and on the hourly ordinates for permanent stations, aiding sometimes on miscellaneous work and copying.

Miss Turnbull has been employed copying, tracing, tabulating tides, and sometimes on easy reductions.

Mr. Downes, by a special contract, was predicting for certain places on the Atlantic Coast, but died before the work was completed.

Mr. Spaulding computed the predictions for Boston, as he has done in past years, in addition to his services as a tidal observer at North Haven.

R. S. AVERY,
In Charge Tidal Division.

R. D. CUTTS, Esq.,
Assistant in Charge of Office and Topography.

ANNUAL REPORT OF THE DRAWING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1883.

DRAWING DIVISION, COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1883.

DEAR SIR: I have the honor to submit the following summary of work performed under my direction in the Drawing Division during the year ending June 30, 1883.

In the detailed statement accompanying is given, in tabular form, a list in geographical sequence of the charts completed, continued, or commenced, with the particular kind of work executed and the names of draughtsmen engaged thereon. In Appendix No. 3 has been incorporated a statement of the information furnished and the names of persons to whom given, in reply to special requests made to this office for tracings, transcripts of records, &c.

The division, has maintained its efficiency, and, by the close, faithful application of its attachés to the duties assigned them, has met all the requirements of the yearly increase in the demands upon its service.

The *personnel* has been about the same as in past years with regard to skill and numbers, and only a few minor changes have taken place.

The photolithographic process, quick and reliable in its results, has become more and more a very important feature with us, and, as usual, much time has been given to the construction and inking of charts and drawings designed for reproduction and publication, by a method which facilitates our efforts to provide the public with charts of every locality at an early date after the completion of the surveys.

The general features of the work allotted to the draughtsmen and other employés are stated below:

Mr. A. Lindenkohl, in the compilation of the finer scale-drawings, has displayed his usual skill and celerity. Most of the small scale charts, especially those requiring rare judgment for their execution, have been intrusted to him, his long experience enabling him to meet successfully the geographical and other difficulties not infrequent in compiling from data of various dates, kinds, and scales. An elaborate map of the United States, from the latest authorities, based upon our own surveys, has been begun by Mr. Lindenkohl, on a scale of ten miles to the inch. A chart of

the harbors of Washington and Georgetown was completed by him during the year. He has kept the Progress Sketches supplied with all additions up to date.

Mr. H. Lindenkohl, equally accomplished as draughtsman and engraver, has been occupied principally with the preparation of standard drawings of harbor and coast charts for photolithographing, besides engraving on stone several diagrams and sketches required for illustrations to the appendices accompanying the annual report of the Survey.

Mr. Louis Karcher, notwithstanding the great number of projections called for during the year, has executed most of them with dispatch, and found time to construct the many projects needed by the office, and to execute numerous diagrams and other miscellaneous work.

Mr. E. J. Sommer was employed in a variety of ways: making projections on paper and on copper, preparing tracings, and reducing topography and hydrography.

Mr. P. Erichsen has drawn topographical details on engraved outlines, and made drawings of instruments of precision, perspective and otherwise, some of them of quite an elaborate character.

Mr. C. Junken, whom the Superintendent had detailed for special duty in surveying and mapping a tract of land in Wythe County, Virginia, for the United States Fish Commission, was engaged in the performance thereof until its completion, in July, when he reported back to the division, whence he was detached November 11, and assigned to the Hydrographic Inspector. Between July and November, Mr. Junken gave his attention to hydrographic reductions.

Mr. T. J. O'Sullivan has been engaged almost exclusively in the preparation of charts and drawings for publication by photolithography. He also made diagrams, projects, and tracings, and did general lettering.

Mr. A. B. Graham, in addition to constructing projections for the use of hydrographic parties, has reduced and transferred the shore-line upon nearly all projections made in the office during the year. Triangulation sketches, diagrams, &c., have all received a share of Mr. Graham's time.

Mr. J. B. Tyrrell was employed wholly in coloring buoys, light-houses, and other aids to navigation upon the printed charts until March 21, 1883, when he was transferred and worked under the direction of Assistant Andrew Braid.

Miss F. Cadel also did duty in this division, in coloring buoys and light-houses, until March 21, 1883, when she was transferred to the immediate direction of Assistant Andrew Braid.

Messrs. E. H. Fowler and E. Molkow, who were detached from the Drawing Division, in July, 1881, and assigned to the then newly created Division of Topography, were returned to this division in October, 1882, and have been engaged since then mostly in inking plane-table sheets.

Mr. V. J. Fagin joined the division in February, 1883, and performed the clerical duties required by me quite acceptably till the 12th of March, following, at which date he was transferred to the office of the disbursing agent.

Mr. J. C. Barr became re-attached to the division on the 12th of March, 1883, since which time he has acted as clerk, and done duty in coloring published charts and making corrections, when required, to the aids to navigation on the same.

Yours, respectfully,

W. T. BRIGHT,
In Charge Drawing Division.

R. D. CUTTS, Esq.,
Assistant in Charge of Office and Topography.

DRAWING DIVISION.

Charts completed or in progress during the year ending June 30, 1883.

1. Topography. 2. Hydrography. 3. Drawing for photolithographic reproduction. 4. Inking and lettering plane-table sheets. 5. Engraving on stone. 6. Compiling. 7. Verification. 8. Diagrams. 9. Measuring area of engraved sand.

Number of charts. Series.	Catalogue.	Titles of charts.	Scales.	Draughtsman.	Remarks.
		PACIFIC COAST SAILING CHARTS.			
	600[1]	San Diego to San Francisco (with subsketches)	1-120,000	2. C. Junken	Commenced.
	600[2]	San Francisco to Straits of Fuca (with subsketches).	1-120,000	2. C. Junken	Do.
		GENERAL COAST CHARTS.			
II	7	Cape Ann to Gay Head	1-400,000	2. A. Lindenkohl	Additions.
III	8	Gay Head to Cape Henlopen	1-400,000	2. A. Lindenkohl	Do.
VI	11	Cape Hatteras to Cape Romain	1-400,000	2. A. Lindenkohl	Do.
	162a	Cape Canaveral to Jupiter Inlet light-house	1-200,000	2. E. J. Sommer	Photolithograph; completed.
XV	20	Atchafalaya Bay to Galveston, Tex	1-400,000	1. C. Junken	Commenced.
XVI	21	Galveston to the Rio Grande	1-400,000	1. A. Lindenkohl.	Completed.
6	676	Western coast of San Francisco to Point Arena	1-200,000	2. A. Lindenkohl	Do.
11	681	Cascade Head to Shoalwater Bay	1-200,000	1, 2. A. Lindenkohl	In progress.
		COAST CHARTS.			
2	102	Seal Island Light to Petit Manan Light	1-80,000	1. A. Lindenkohl. 1. H. Lindenkohl.	Commenced.
3	103	Frenchman's and Blue Hill Bays, Me	1-80,000	1. C. Junken. 1. P. Erichsen. 1. A. Lindenkohl. 2. E. J. Sommer.	Completed.
45	145	Cape Hatteras to Ocracoke Inlet, N. C	1-80,000	2. A. Lindenkohl. 7. C. Junken	Do.
48	148	Bogue Inlet to New Topsail Inlet, N. C	1-80,000	1. P. Erichsen	In progress.
51	151	Tubbs Inlet toward Winyah, S. C	1-80,000	2. A. Lindenkohl	Completed.
52	152	Winyah Bay, Cape Romain, &c., S. C	1-80,000	2. A. Lindenkohl	Do.
53	153	Winyah Bay to Long Island Sound, S. C.	1-80,000	2. T. J. O'Sullivan	Do.
58	158	Cumberland Sound to Saint John's River	1-80,000	9. P. Erichsen	Do.
83	183	Saint George's Island to Cape San Blas, Fla	1-80,000	2. E. J. Sommer	Do.
84	184	Cape San Blas to Saint Andrew's Bay, Fla	1-80,000	2. E. J. Sommer	Continued.
110	210	Corpus Christi Bay southward, Tex	1-80,000	1. A. Lindenkohl. 7. H. Lindenkohl	In progress.
111	211	Coast of Texas southward of Corpus Christi Bay, Tex.	1-80,000	1. A. Lindenkohl	Completed.
		HARBOR CHARTS.			
	308	Approaches to Blue Hill Bay and Eggemoggin Reach.	1-40,000	1. P. Erichsen	Completed.
	344	Mononoy Passage to Nantucket Sound	1-40,000	1. A. Lindenkohl (new edition)	Do.
	369	New York Entrance	1-40,000	2. E. J. Sommer; A. Lindenkohl (new edition).	Do.
	361a	Hart and City Islands, Long Island Sound	1-10,000	1, 2. E. J. Sommer	In progress.
	540a	Jamaica Bay and Rockaway Inlet	1-25,000	2. E. J. Sommer (new edition)	Completed.
1	126b	Delaware River, Cherry Island Flats to Bridesburg.	1-40,000	2. C. Junken (sailing lines, &c.) 1, 2, 3. H. Lindenkohl.	Do.
2	126c	Delaware River, Bombay Hook Island to Cherry Island Flats.	1-40,000	1, 2, 3. H. Lindenkohl. 2. C. Junken. 1. A. Lindenkohl.	Do.
	391a	Harbors of Washington and Georgetown	1-15,840	1, 2. A. Lindenkohl. 1, 2, 3. H. Lindenkohl.	Do.
5	401c	James River, Kingsland Creek to Richmond	1-20,000	1. E. J. Sommer	Do.
	404b	Norfolk Harbor, Va	1-10,000	1, 2. H. Lindenkohl (new edition)	Do.
3	455b	Saint John's River, Jacksonville to Hibernia	1-40,000	2. A. Lindenkohl	Do.
4	455c	Saint John's River, Hibernia to Racey's Point	1-40,000	1, 2. E. J. Sommer	Do.
	438	Beaufort River, inside passage between Port Royal and Saint Helena Sound, S. C.	1-40,000	2. A. Lindenkohl	Additions.
13	464e	Florida, inside passage, Indian River	1-250,000	1, 2, 3. T. J. O'Sullivan	In progress.
	469	Key West Harbor, Fla., with subsketch	1-50-000	2. A. Lindenkohl	Completed.
	621a	San Francisco entrance, Cal	1-40,000	1. E. J. Sommer (new edition)	Do.
	607	San Clemente, southwest anchorage, Cal	1-30,000	1, 2, 3. H. Lindenkohl	Do.
	607	San Clemente, southeast anchorage, Cal	1-30,000	1, 2, 3. H. Lindenkohl	Do.

DRAWING DIVISION—Continued.

Number of charts. Series.	Number of charts. Catalogue.	Titles of charts.	Scales.	Draughtsman.	Remarks.
		HARBOR CHARTS—Continued.			
	607[2]	Cuyler's Harbor, Cal	1-20,000	1, 2, 3. H. Lindenkohl (new edition)	
	607[1]	Prisoner's Harbor, Cal	1-20,000	1, 2, 3. H. Lindenkohl (new edition)	Completed.
		Port Discovery and Washington Harbor	1-40,000	1, 2. E. H. Fowler	Do.
		MISCELLANEOUS.			
		Compiling State maps of New York, Pennsylvania, and Maryland.	10 miles to the inch.	6. A. Lindenkohl	
		Map for Treasury Department, customs districts, Maine to New York.	1-1,250,000	6. H. Lindenkohl	
		SKETCHES.			
		Revillagigedo channel sketches, or Tongas Narrows, Alaska.		6. A. B. Graham	
		Granite Cove, Alaska, and Whitewater Bay, Alaska.		6. H. Lindenkohl	
		Sea otter and cod fishing-grounds, Kachekmak Bay, Alaska.		6. H. Lindenkohl. 7. T. J. O'Sullivan	
		Juneau Harbor, Fritz Cove, Wachusett Cove, Alaska.		6. T. J. O'Sullivan	
		Security Bay, Alaska		6. T. J. O'Sullivan	
		Cape Henlopen and vicinity	1-10,000	4. E. H. Fowler	
		Point Buchon, Cal	1-10,000	4. E. Molkow	
		DIAGRAMS.			
		Plan of new base apparatus		P. Erichsen; E. J. Sommer	
		Tide-predicting machine, plan of		P. Erichsen	
		Drawing apparatus for weights and measures, report 1882.		P. Erichsen	
		Plan of apparatus for testing micrometer screws		P. Erichsen	
		Plan of comparing apparatus		P. Erichsen	
		Yolo base, Cal., three sketches (report of 1882)		3. T. J. O'Sullivan	
		Oyster beds of Chesapeake Bay (sketch of)		8. T. J. O'Sullivan	
		Magnetic charts and diagrams		5. H. Lindenkohl	
		Western part of North Atlantic Ocean, model of bottom.		H. Lindenkohl	
		Sketches on stone, tide station, Pacific coast, for report of 1882.		5. H. Lindenkohl	
		Magnetic maps on stone for report of 1882		5. H. Lindenkohl	
		Maps of transcontinental line of spirit-levels, Sandy Hook, New Jersey, to Saint Louis, Mo.		8. E. Molkow. 5. H. Lindenkohl	

REPORT OF THE ENGRAVING DIVISION FOR THE YEAR ENDING JUNE 30, 1883.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1883.

SIR: I respectfully submit the following report of work executed in the Engraving Division during the fiscal year ending June 30, 1883.

Number of plates completed:		
Charts	27	
Sketches and illustrations	5	
		32
Number of plates continued:		
Charts	19	
Sketches and illustrations	3	
		22

Number of plates commenced:		
Charts	13	
New editions of charts	2	
Sketches and illustrations	34	
	——	49
Number of plates corrected:		
Charts	423	
Sketches	14	
	——	437
Total number of plates worked upon		540
Number of unfinished plates on hand at the close of the year:		
Charts	41	
Sketches and illustrations	50	
	——	91

Of the 27 completed chart plates, 10 are new charts, 13 new editions, and 4 reissues.

I append hereto a list showing in detail the plates that were completed, continued, or commenced during the year.

The corrections to the plates of the published charts were not so numerous as during the preceding year, although this class of corrections required the handling of 423 plates.

As a rule, a few hour's work suffices to make the changes indicated.

In addition to the engraving, we have had the usual amount of cleaning electrotypes, erasures from altos, drawing and arranging titles, general lettering and notes, marking instruments, &c.

The force of the division remains as at the beginning of the year, and has been employed as follows: Messrs. J. Enthoffer, A. Sengteller, and R. F. Bartle, on topography; Messrs. E. A. Maedel, A. Petersen, J. G. Thompson, and F. Courtenay, on lettering; Messrs. W. A. Thompson and H. C. Evans, on topography and sanding; Messrs. E. H. Sipe, W. H. Davis, and A. C. Reubsam, on lettering and miscellaneous corrections; Messrs. H. M. Knight and F. W. Benner, on sanding; and Mr. T. Wasserbach, on sanding and miscellaneous corrections.

The work of the printing office has been conducted as described in my report of last year. The addition to the force of one helper has permitted running the third press almost constantly since that time. The two large presses have remained, as heretofore, in charge of Mr. F. Moore and D. N. Hoover. The third press was placed in charge of Mr. J. L. Smith, and has been used principally in printing the Coast Pilot work and the smaller chart plates.

The new paper press mounted in April has proved most satisfactory. It does all that the builders claimed for it and greatly enhances the artistic appearance of the charts.

The great annoyance arising from sending plates to lithographers for transfer proofs, led me to attempt pulling our own transfers. I am pleased to report the result as entirely satisfactory, and am confident we can now furnish transfers of the finest work, that in the hands of skilled workmen will not fail on the stone.

The following is a summary of the printing during the year:

Number of impressions for chart room	26,767
Number of impressions for Assistant in charge	3,627
Number of impressions for Engraving Division	1,853
Number of impressions for Hydrographic Inspector	1,726
Number of impressions for lithographers (transfer proof)	182
Number of impressions of Atlantic Coast Pilot charts and views	14,165
	48,320

The general superintendence of the electrotyping of the office plates, placed under my charge in December last, has received my close attention. The plans you have approved for increasing the facilities of this work are in preparation, and it is my hope will be in successful operation sufficiently early to show a marked increase in the coming year's results. It is a question of quantity, as we can hardly expect any improvement in the excellent quality of the plates now turned out.

Dr. A. Zumbrock, electrotypist, furnishes the following statistics of the electrotyping and photographing during the year:

For the Survey, 18 altos weighing 401 pounds, with a plate surface of 21,012 square inches, and 21 bassos weighing 710½ pounds, with a plate surface of 23,762 square inches.

For the Hydrographic Office, United States Navy, 2 altos weighing 44 pounds, with a surface of 2,264 square inches, and 4 bassos weighing 108 pounds, with a surface of 3,426 square inches.

For the Engineer's Office, United States Army, 10 altos weighing 220 pounds, with a surface of 11,472 square inches, and 10 bassos weighing 365 pounds, with a surface of 11,472 square inches.

Total number of plates electrotyped, sixty-five, weighing 1,848½ pounds, with a plate surface of 73,408 square inches.

Besides these electrotypes an alto and basso were made of a seal for the General Land Office, and two clock faces for instrument shop; 69 plates were steel-faced, 56 negatives were taken of maps and instruments, and 163 prints were made.

Mr. J. H. Smoot has attended to the clerical duties of the division in a most satisfactory manner.

Yours, very respectfully,

HERBERT G. OGDEN,
Assistant in Charge of Engraving Division.

R. D. CUTTS, Esq.,
Assistant in Charge of Office and Topography.

Plates completed, continued, or commenced during the fiscal year ending June 30, 1883.

1. Outline. 2. Topography. 3. Sounding. 4. Lettering.

Catalogue No.	Plate No.	Title.	Scale.	Engravers.	Date of completion or issue.
		COMPLETED.			
11	1429	Cape Hatteras to Cape Romain	1-400,000	1, 2. W. A. Thompson. 4. J. G. Thompson	November 23, 1882.
13	1456	Saint Mary's entrance to Cape Canaveral	1-400,000	1, 3. W. A. Thompson. 4. E. A. Maedel, A. Petersen, and J. G. Thompson.	October 24, 1882.
103	1113	Frenchman's and Blue Hill Bays	1-80,000	1, 2. J. Enthoffer. 3. H. M. Knight. 4. E. A. Maedel and J. G. Thompson.	May 31, 1883.
142	1272	Pamplico Sound, Roanoke Island to Hatteras Inlet.	1-80,000	1, 3. W. A. Thompson. 3. F. W. Benner. 4. E. A. Maedel, J. G. Thompson, and A. C. Ruebsam.	June, 1883.
158	1234	Saint Mary's entrance southward to latitude 30° north.	1-80,000	1, 2, 3. W. A. Thompson. 4. J. G. Thompson and T. Wasserbach.	November 29, 1882.
159	1411	Saint Augustine Inlet to Halifax River	1-80,000	4. J. G. Thompson and A. C. Ruebsam	August 4, 1882.
160	1526	Halifax River to Mosquito Lagoon	1-80,000	4. J. G. Thompson and T. Wasserbach	September 23, 1882.
161	1602	Cape Canaveral, Fla	1-80,000	3. W. A. Thompson, R. F. Bartle. 4. E. A. Maedel, A. Petersen, and J. G. Thompson.	March 17, 1883.
344	1716	Monomoy Passage, Mass	1-40,000	1, 2, 3. H. C. Evans. 4. F. Courtenay and A. C. Ruebsam.	June, 1883.
371*a*	1713	Topographical map, West Point, N. Y	1-4,800	1, 2. H. C. Evans. 4. E. A. Maedel	June 11, 1883.
		EDITION OF 1882.			
129	1286	Chincoteague Inlet to Hog Island Light	1-80,000	1, 2, 3. H. M. Knight. 4. E. H. Sipe	December, 1882.
348	779	Wood's Holl, Mass	1-20,000	4. T. Wasserbach	July, 1882.
352	1033	Port of Providence, R. I	1-10,000	3, 4. T. Wasserbach	September, 1882.
390	1148	Potomac River No. 3, Lower Cedar Point to Indian Head.	1-80,000	1, 2. A. Sengteller. 3. W. A. Thompson. 4. J. G. Thompson, W. H. Davis, and A. C. Ruebsam.	November, 1882.
488	699	Saint Andrew's Bay, Fla	1-40,000	3. W. A. Thompson. 4. W. H. Davis and A. C. Ruebsam.	November, 1882.
623	1006	San Pablo Bay, Cal		3, 4. T. Wasserbach. 4. A. C. Ruebsam	November, 1882.

Plates completed, continued, or commenced during the fiscal year ending June 30, 1883—Continued.

Catalogue No.	Plate No.	Title.	Scale.	Engravers.	Date of completion or issue.
		REISSUED 1882.			
349	1005	Sippican Harbor	1-20,000	4. W. H. Davis	December, 1882.
622	1074	San Francisco Bay, Cal	1-50,000	4. W. H. Davis and A. C. Ruebsam	November, 1882.
		EDITION OF 1883.			
183	1681	Apalachicola Bay to Cape San Blas	1-80,000	4. A. Petersen and A. C. Ruebsam	May, 1883.
186	1290	Choctawhatchee Inlet to Pensacola entrance	1-80,000	3. W. A. Thompson and H. M. Knight. 4. H. M. Knight.	January, 1883.
346	169	Edgartown Harbor	1-20,000	1, 2, 3. W. A. Thompson. 4. H. W. Davis	January, 1883.
369	1639	New York Bay and Harbor (upper)	1-40,000	1, 3. H. M. Knight. 2, 3. W. A. Thompson. 4. E. A. Maedel and H. M. Knight.	June, 1883.
369	1641	New York Bay and Harbor (lower)	1-40,000	1, 2. W. A. Thompson. 4. E. A. Maedel	June, 1883.
391	1319	Potomac River No. 4, Indian Head to Georgetown.	1-40,000	1, 2. E. J. Enthoffer. 2. W. A. Thompson. 3, 4. T. Wasserbach. 4. A. C. Ruebsam.	February, 1883.
643	931	Gray's Harbor	1-40,000	1, 3, 4. J. G. Thompson	June, 1883.
		REISSUED 1883.			
421	1018	Core Sound and Straits	1-40,000	4. W. H. Davis	June, 1883.
629	864	Drake's Bay	1-40,000	4. H. M. Knight	June, 1883.
		MISCELLANEOUS.			
	1697	Atlantic Coast Pilot, vol. 1, entrance to Portland Harbor.		Etching by J. R. Barker. 4. W. H. Davis	October, 1882.
	1703	Topographical specimen, The Dalles, Columbia River.		4. E. A. Maedel and J. G. Thompson	September 1882.
	1692	Plate of squares, decimal division		4. W. A. Thompson and E. H. Sipe	July, 1882.
	1708	Magnetic or chart compass		4. J. G. Thompson	August, 1882.
	1743	Conventional signs and symbols		2. W. A. Thompson. 4. H. M. Knight	May, 1883.
D	1653	Gulf of Mexico	1-2,100,000	1, 4. J. G. Thompson	
17	1603	Tampa Bay to Cape San Blas	1-400,000	4. A. Petersen	
21	1090	Galveston to the Rio Grande	1-400,000	1, 2, 3. W. A. Thompson. 3. H. M. Knight. 4. E. A. Maedel and A. Petersen.	
143	1190	Pamplico Sound, Ocracoke Inlet to Pamplico River.	1-80,000	3. H. M. Knight and F. W. Benner. 4. E. A. Maedel.	
153	1503	Winyah Bay to Long Island	1-80,000	4. F. Courtenay	
175	1093	Charlotte Harbor and San Carlos Bay	1-80,000	3. H. C. Evans and H. M. Knight. 4. E. A. Maedel and A. Petersen.	
182	1447	Apalachee Bay and Saint George's Sound	1-80,000	3. H. C. Evans. 2, 3. H. M. Knight. 4. E. A. Maedel, F. Courtenay, and A. C. Ruebsam.	
184	1601	Saint Joseph's Bay to Saint Andrew's Bay	1-80,000	4. F. Courtenay	
185	1498	Saint Andrew's Bay to Choctawhatchee Inlet	1-80,000	1, 2. H. C. Evans and W. A. Thompson. 3. T. Wasserbach. 4. A. Petersen and A. C. Ruebsam.	
192	1537	Chandeleur and Breton Island Sounds	1-80,000	1, 2, 3. W. A. Thompson	
195	1314	Mississippi River, from Grand Prairie to New Orleans.	1-80,000	4. H. M. Knight	
208	1247	Pass Cavallo, Lavaca and San Antonio Bays	1-80,000	3. F. W. Benner. 4. A. C. Ruebsam	
209	1248	Aransas Pass, Aransas and Copano Bays	1-80,000	4. A. C. Ruebsam	
306	1186	Frenchman's Bay and Somes' Sound	1-40,000	2. R. F. Bartle. 3. H. C. Evans. 4. A. Petersen and E. H. Sipe.	
307	1265	Blue Hill and Union River Bays	1-40,000	1, 2. H. C. Evans. 4. A. Petersen, R. F. Bartle, and E. H. Sipe.	
308	1376	Approaches to Blue Hill Bay and Eggemoggin Reach.	1-40,000	2. R. F. Bartle. 4. J. G. Thompson	
401*d*	1664	James River, No. 4, City Point to Kingland's Creek.	1-20,000	2. E. J. Enthoffer. 3. H. M. Knight	
401*c*	1679	James River, No. 5, Kingland's Creek to Richmond.	1-20,000	1, 2. J. Enthoffer. 2. E. J. Enthoffer	
621*a*	1532	San Francisco Bay entrance	1-40,000	1, 2. W. A. Thompson. 4. A. Petersen	
	1565	Alaska Coast Pilot chart, Cape Mudge to Cape Commerell.	1-510,720	4. A. C. Ruebsam	

Plates completed, continued, or commenced during the fiscal year ending June 30, 1883—Continued.

Catalogue No.	Plate No.	Title.	Scale.	Engravers	Date of completion or issue.
		CONTINUED—Continued.			
	1566	Alaska Coast Pilot chart, Cape Commerell to Point Walker.	1–510, 720	4. A. C. Ruebsam	
	1567	Alaska Coast Pilot chart, Point Walker to Swanson Bay.	1–510, 720	4. A. C. Ruebsam	
		COMMENCED.			
102	1742	Seal Island to Petit Manan	1–80, 000	1, 2. J. Enthoffer. 4. J. G. Thompson	
145	1725	Cape Hatteras	1–80, 000	4. A. Petersen	
151	1695	Little River Inlet and the coast of Long Bay	1–80, 000	1, 2. J. Enthoffer. 2. W. A. Thompson. 4. E. A. Maedel, J. G. Thompson, and F. Courtenay.	
152	1696	Winyah Bay to Cape Romain, &c., east part	1–80, 000	1, 2. A. Sengteller	
180	1746	Cedar Keys to Dead Man's Bay	1–80, 000	1, 2. H. C. Evans. 4. A. C. Ruebsam	
212	1715	Brazos Santiago, &c	1–80, 000	1. E. J. Enthoffer. 2. J. Enthoffer. 4. A. Petersen, F. Courtenay, and A. C. Ruebsam.	
344	1716	Monomoy Passage, Mass	1–40, 000	1, 2, 3. H. C. Evans. 4. F. Courtenay and A. C. Ruebsam.	
371 *a*	1713	Topographical map, West Point, N. Y	1–4, 800	1, 2. H. Evans. 4. E. A. Maedel	
455 *b*	1704	Saint John's River, No. 3, Jacksonville to Hibernia.	1–40, 000	1, 2, 3. R. F. Bartle. 4. F. Courtenay, E. A. Maedel, and J. G. Thompson.	
455 *c*	1729	Saint John's River, No. 4, Hibernia to Racey's Point.	1–40, 000	1, 2. R. F. Bartle. 4. E. A. Maedel and J. G. Thompson.	
600 *b*	1754	San Francisco to Cape Flattery	1–1, 200, 000		
600 *a*	1755	San Diego to San Francisco	1–1, 200, 000		
676	1741	San Francisco to Point Arena	1–200, 000	1, 2. W. A. Thompson	
		NEW EDITIONS.			
469	1736	Key West Harbor	1–50, 000	4. H. C. Evans	
626	1758	Suisun Bay	1–40, 000	4. T. Wasserbach	
		Atlantic Coast Pilot view:			
	1717	Volume 1, Monhegan Island from the eastward.		Etching by J. R. Barker	
	1722	Volume 1, approaches to Muscle Ridge Channel.		do	
	1721	Volume 1, Muscle Ridge Channel off Metinic Island.		do	
	1720	Volume 1, entrance to Carver's Harbor, &c		do	
	1718	Volume 1, Muscle Ridge Channel and Rockland Harbor.		do	
	1707	Volume 1, approaches to Saint George's River, &c.		do	
	1709	Volume 1, approaches to John's Bay, &c		do	
	1710	Volume 1, entrance to Sheepscot River, &c		do	
	1711	Volume 1, approaches to Kennebec and Sheepscot Rivers.		do	
	1698	Volume 1, Wood Island		do	
	1705	Volume 1, Cape Ann from eastward and northward.		do	
	1694	Volume 1, entrance to Salem by main channel, &c.		do	
	1702	Volume 3, Fort Washington, Potomac River		do	
	1701	Volume 4, entrance to North Edisto River, &c		do	
	1723	Volume 4, Beaufort, S. C		do	
	1726	Volume 4, Tybee entrance, Tybee Roads, &c		do	
	1728	Volume 4, city of Savannah and Thunderbolt		do	
	1732	Volume 4, Wassaw entrance, Ossabaw Sound, &c.		do	
	1733	Volume 4, Saint Catherine's Sound, &c		do	
	1735	Volume 4, Doboy and Altamaha Sounds, &c		do	
	1737	Volume 4, Saint Simon's Sound and Brunswick Harbor, Ga.		do	

Plates completed, continued, or commenced during the fiscal year ending June 30, 1883—Continued.

Catalogue No.	Plate No.	Title.	Scale.	Engravers.	Date of completion or issue.
		NEW EDITIONS—Continued.			
		Atlantic Coast Pilot view:			
	1739	Volume 4, Saint Andrew's and Cumberland Sounds, &c.	....	Etching by J. R. Barker	
	1744	Volume 4, Old and New Fernandina	....	do	
	1759	Volume 4, Saint John's River entrance, &c	....	do	
	1745	Progress sketch, Hudson and Saint Croix Rivers, extension western part.	....	4. E. H. Sipe	
	1749	Maryland and Georgia base-line, north part, extension northwest corner.	....	do	
	1753	Progress sketch between Long Island and the Blue Ridge, extension southward.	....	do	
	1692	Plate of squares, decimal divisions	....	4. W. A. Thompson and E. H. Sipe	
	1699	Topographical specimen Cathlamet Channel	....	Etching by J. R. Barker	
	1700	Topographical view of Cape Disappointment	....	do	
	1743	Conventional signs and symbols	....	2. W. A. Thompson. 4. H. M. Knight	
	1750	Topographical specimen, Plymouth, Mass	....	Selmar Siebert	
	1751	Topographical specimen Plymouth contour lines.	....	do	
	1708	Magnetic or chart compass	....	4. J. G. Thompson	

ANNUAL REPORT OF THE MISCELLANEOUS DIVISION FOR THE YEAR ENDING JUNE 30, 1883.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., August 1, 1883.

DEAR SIR: I have the honor to submit herewith the annual report of this division for the year ending June 30, 1883:

The work of the division has included, as heretofore, the correspondence with sale agents relating to the supply and sale of Charts, Coast Pilots, and Tide Tables; the purchase, custody, and issue of stationery; the printing and distribution of the blank forms, record books, &c., used in the office and in the field-work, and of the annual reports and other publications of the Survey; the supervision and care of the office buildings; the general charge of camp equipage, &c.; the general direction of work in the carpenter-shop, and such other special duties as have been assigned from time to time by the Superintendent and the assistant in charge of office and topography.

Satisfactory progress was made during the year in the publication of the Annual Reports, which from a variety of causes had fallen far behind current dates, and those for the years 1878, 1879, and 1880 were printed and distributed. The text of the Report for 1881 was also printed, but its issue before the close of the year was prevented by the failure of the contractor for the lithographing to furnish the sketches and illustrations.

There were received from the Public Printer during the year the following aggregates of publications of the Survey:

	Copies.
Annual Reports for 1878, 1879, and 1880	7,054
Appendices to the Annual Reports (extra copies)	10,200
Tide Tables for the Atlantic and Pacific coasts for 1884	4,500
Catalogue of Charts, edition of 1883	600
Notices to Mariners, Nos. 34, 35, 36, 37, 38, and 39.	3,000
Atlantic Coast Pilot, Subdivisions 2, 4, 5, and 6 (second editions)	848
Deep-Sea Sounding and Dredging (reprint)	374
A Treatise on Projections	1,000
General Instructions for Hydrographic Work	500
Summary of Report of Superintendent for 1882	500

A detailed statement concerning the foregoing publications is appended hereto.

Subdivision 15 of the Atlantic Coast Pilot was sent to press.

The usual distribution of the various publications of the Survey was made to the Departments of Government, and the sale agencies were regularly supplied with charts, the Atlantic Coast Pilot and its subdivisions, and the Tide Tables for the Atlantic and Pacific coasts. The Appendices to the Annual Reports, of which extra copies in pamphlet form have been published for free distribution, were furnished to all proper applicants. The Notices to Mariners were also distributed gratuitously, as soon as practicable after their publication.

Three thousand and seventy-six copies of the Annual Reports were distributed during the year; also 696 copies of the Atlantic Coast Pilot, including subdivisions.

Second editions of the following subdivisions of the Atlantic Coast Pilot were published, viz: No. 2. "Frenchman's Bay to Isle au Haut;" No. 4. "White Head Island to Cape Small Point;" No. 5. "Cape Small Point to Cape Ann;" No. 6. "Cape Ann to Cohasset." The edition of "Deep-Sea Sounding and Dredging" having been exhausted, a reprint of that work, with the addition of a supplementary chapter on improvements made in the apparatus used in deep-sea work, subsequent to the publication of the original, was brought out.

New editions of "General Instructions for Hydrographic Work," and of the "Catalogue of Charts," were also published.

There were received in the chart room, during the year, 31,527 sheets of charts, of which 24,720 were copper-plate impressions, and 6,757 were printed from stone. Twelve thousand five hundred and nine copies were issued to the several Departments of Government and to Senators and Representatives, and 16,612 copies were supplied to sale agents. The total distribution of charts during the year was 32,012 copies, being an increase of 2,963 copies over the preceding year. (See statement appended hereto.)

Mr. Hugo G. Eichholtz has continued in charge of the chart-room, and the issue of charts has been made under his immediate supervision.

The carpenter-work of the office, including the wood-work of instruments and their packing for transportation, the construction of frames, vats, &c., for the laboratory, repairs of furniture, and repairs to the office buildings, &c., was done by Mr. A. Yeatman, assisted, as heretofore, by Messrs. G. F. Cox and G. W. Clarvoe.

Mr. R. T. Bassett has been in charge of the work in the map-mounting room, and the duties of janitor were performed by Mr. N. Y. Cavitt.

The fidelity and zeal displayed in the discharge of their duties by the messengers and laborers employed in the office deserve special commendation.

Yours, respectfully,

M. W. WINES,
Chief of Miscellaneous Division.

R. D. CUTTS, Esq.,
Assistant in Charge of Office and Topography.

List of the publications of the Coast and Geodetic Survey received from the Public Printer during the fiscal year ending June 30, 1883.

Name of publication.	No. of copies.	Name of publication.	No. of copies.
Annual Report for 1878	1,306	Atlantic Coast Pilot, Subdivision 4—"White Head Island to Cape Small Point" (second edition).	200
Annual Report for 1879	2,966		
Annual Report for 1880	2,782	Atlantic Coast Pilot, Subdivision 5—"Cape Small Point to Cape Ann" (second edition).	200
Tide Tables, Atlantic coast, for 1884	2,500		
Tide Tables, Pacific coast, for 1884	2,000	Atlantic Coast Pilot, Subdivision 6—"Cape Ann to Cohasset" (second edition.)	250
Catalogue of Charts (edition of 1883)	600		
Atlantic Coast Pilot, Subdivision 2—"Frenchman's Bay to Isle au Haut."	198	Deep-Sea Sounding and Dredging (reprint)	374
		A Treatise on Projections	1,000

List of the publications of the Coast and Geodetic Survey received from the Public Printer, &c.—Cont'd.

Name of publication.	No. of copies.	Name of publication.	No. of copies.
General Instructions for Hydrographic Work	500	No. 18—"An attempt to solve the problem of the first landing place of Columbus in the New World."	1,000
Summary of Report of Superintendent for 1882 (8vo, paper)	500	No. 19—"An inquiry into the variation of the compass off the Bahama Islands at the time of the landfall of Columbus in 1492."	1,000
NOTICES TO MARINERS.		APPENDICES TO REPORT FOR 1881.	
No. 34—"Dangerous rock in eastern entrance to Fisher's Island Sound."	500	No. 6—"General index of scientific papers contained in the annual reports of the United States Coast and Geodetic Survey from 1845 to 1880, inclusive."	1,000
No. 35—"Dangerous rocks in western part of Fisher's Island Sound, approaches to New London and Mystic Harbors."	500	No. 7—"Type forms of topography, Columbia River"	200
No. 36—"Sunken wreck in the track of vessels along the New Jersey coast."	500	No. 8—"Directions for measurement of terrestrial magnetism."	1,000
No. 37—"Wreck in the track of vessels along the east coast of Florida."	500	No. 9—"Terrestrial magnetism. Collection of results for declination, dip, and intensity from observations made by the United States Coast and Geodetic Survey between 1833 and July, 1882."	500
No. 38—"Discovery of a rock in Surge (or Southern) Narrows, Peril Strait, Southeast Alaska."	500	No. 10—"Meteorological researches (Part 3), barometric hypsometry and reduction of the barometer to the sea level."	500
No. 39—"Wreck in the track of coasting vessels off New Jersey."	500	No. 11—"Report on the oyster beds of the James River, Va., and of Tangier and Pocomoke Sounds, Maryland and Virginia."	500
APPENDICES TO REPORT FOR 1880.		No. 12—"On the length of a nautical mile"	500
No. 9—"Comparison of the surveys of the Delaware River in front of Philadelphia, 1843 and 1878."	300	No. 13—"On a method of readily transferring the underground terminal marks of a base line."	500
No. 13—"A treatise on the plane table and its use in topograpical surveying."	1,000	Nos. 14, 15, 16, and 17 (bound together)—"Pendulum experiments."	500
No. 14—"Determination of time, longitude, latitude, and azimuth."	800	No. 18—"Report on a new rule for currents in Delaware Bay and River."	300
No. 15—"A review of various projections for charts in connection with the polyconic projection used in the Coast and Geodetic Survey."	300		
No. 17—"An account of a perfected form of the contact-slide base apparatus used in the Coast and Geodetic Survey."	300		

Report of charts received in and issued from chart room during the fiscal year ending June 30, 1883.

To whom issued.	Number of sheets.			
	Received.	Issued.	On hand.	
			July 1, 1882.	June 30, 1883.
	31,527		36,256	35,771
Executive Departments		10,601		
Senators and Representatives		1,908		
Institutions		841		
Foreign Governments		464		
Sale agents		16,612		
Miscellaneous		1,586		
Totals	31,527	32,012	36,256	35,771

ARCHIVES. UNITED STATES COAST AND GEODETIC SURVEY OFFICE—ANNUAL REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1883.

SIR: In compliance with the regulations of the Survey, I herewith respectfully submit, in the following tabulated form, the annual report of the receipt and registry in the Archives of all original and duplicate records and computations, topographic and hydrographic sheets, and specimens of sea bottom turned into the office during the fiscal year ending June 30, 1883.

I.—*Records and computations.*

GEODETIC WORK.

	Number of volumes.			
	Original.	Duplicate.	Computations.	Total.
Observations of horizontal angles or directions	137	162	....	299
Observations of vertical angles	22	26	....	48
Descriptions of stations	26	27	....	53
Measurement of base	3	19	....	22
Spirit leveling	35	32	....	67
Geodetic miscellany	26	19	....	45
Computations	....	....	103	103

ASTRONOMICAL WORK.

Observations for latitude	11	13	....	24
Observations for longitude	27	15	....	42
Observations for time	9	5	....	14
Observations for azimuth	9	11	....	20
Astronomical miscellany	7	2	....	9
Computations	....	....	42	42

MAGNETIC WORK.

Observations of terrestial magnetism	10	18	....	28
Computations	....	....	10	10

HYDROGRAPHIC WORK.

Observations for soundings	209	162	....	371
Observations of angles	38	39	....	77
Descriptions of hydrographic signals	11	4	....	15
Specimens of sea bottom	308	....	....	308
Tidal observations	94	76	....	170

II.—*Topographic and hydrographic surveys.*

Original topographic and hydrographic sheets.	Number.
Topographic sheets	16
Hydrographic sheets	54

By referring to the foregoing lists it will be found that there were registered in the Archives during the past fiscal year, 636 volumes of geodetic observations and computations; 151 volumes astronomical observations and computations; 38 volumes magnetic observations and computations; 633 volumes hydrographic observations; 308 specimens of sea bottom; 16 original topographic sheets, and 54 original hydrographic sheets, making an aggregate, in volumes, specimens, and sheets, combined, of 1,836.

Respectfully submitted.

GORDON A. STEWART,
Custodian.

RICHARD D. CUTTS, Esq.,
Assistant in Charge of Office and Topography.

REPORT OF WORK DONE IN THE INSTRUMENT DIVISION DURING THE YEAR ENDING JUNE 30, 1883.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1883.

DEAR SIR: I have the honor herewith to submit a report of work done in the instrument shop during the last fiscal year.

In addition to the usual routine work of keeping the records and superintending the repairing, adjusting, and sending out of instruments, a great part of my time was occupied with the dividing engine and in graduating a number of instruments. The tide-predicting machine was also fully finished, and it is now in perfect order and can be used at any time. During the year I perfected also a new method of closing level vials, an account of which appears in this report.

Of other special work done in the instrument shop, I mention the entire reconstruction, by Mr. John Clark, of Theodolite No. 10 (14-inch Wurdemann); its whole superstructure has been changed, a new graduation having been put on some time ago, and Assistant Granger pronounces it one of the best theodolites in the service.

The larger repeating theodolites have nearly all received new tangent screws.

Mr. E. Eshleman, besides his regular work of getting instruments ready for the field, has reconstructed Theodolites Nos. 82 and 127. The former instrument had had a fall, and although badly injured, it was repaired so thoroughly that the officer who afterward used it pronounces it first class. The instrument received a latitude level and circle, and also a micrometer eye-piece, and is now adapted for time and latitude observations, and it was used on the boundary survey between Pennsylvania and West Virginia.

Mr. P. Vierbuchen overhauled the 4-meter base-bars, and tested and adjusted meter-chains. He also reconstructed a number of the older protractors and commenced the making of 6 new ones.

Louis Fischer rendered valuable assistance to me while working on the dividing engine in taking micrometer readings. He also prepared the silver surfaces ready for graduations. The experimental work on the new machine for grinding fine levels automatically was all done by him under my direction. A description of this machine will be submitted at an early day. An apparatus for testing micrometer screws, which proved of great utility, was also his work.

S. Kearney was kept busy with overhauling all our heliotropes and making back-mirrors and plumb-bobs. He also made all the needed brass work for tripods and telemeters, besides repairing the drawing instruments and executing miscellaneous work called for by the office.

Yours, respectfully,

G. N. SAEGMULLER,
Chief Mechanician.

R. D. CUTTS, Esq.,
Assistant in Charge of Office and Topography.

APPENDIX No. 5.

REPORT OF THE HYDROGRAPHIC INSPECTOR FOR THE YEAR ENDING JUNE 30, 1883.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, August 1, 1883.

SIR: I have the honor to make the following report of hydrography under my charge for the fiscal year ending June, 1883.

The commencement of the year found the vessels situated as follows:

The steamer Blake, Commander J. R. Bartlett, U. S. N., at work—deep-sea soundings—off Montauk Point.

The steamer A. D. Bache, Lieut. Commander E. B. Thomas, U. S. N., at New York preparing for summer's work off New York entrance.

The steamer Gedney, Lieut. Commander W. H. Brownson, U. S. N., at New York preparing for summer's work off New York entrance.

The steamer Endeavor, Lieut. H. B. Mansfield, U. S. N., at work, Delaware River.

The schooner Eagre, Lieut. H. G. O. Colby, U. S. N., at work, coast of Maine.

The schooner Silliman, Lieut. E. M. Hughes, U. S. N., at New York preparing for summer's work, Long Island Sound.

The schooner Drift, Master J. C. Fremont, jr., U. S. N., at New York preparing for work, Long Island Sound.

The schooner Ready, Assistant H. L. Marindin, commanding, preparing for work in Delaware River.

On the Pacific coast:

The steamer Hassler, Lieut. Commander H. E. Nichols, U. S. N., commanding, at work in Alaska waters.

The steamer McArthur, Lieut. W. T. Swinburne, U. S. N., commanding, at Mare Island preparing for summer's work.

The schooner Earnest, Lieut. Perry Garst, U. S. N., commanding, at Olympia, Washington Territory, preparing for summer's work.

All the remaining vessels of the Survey were laid up or under repairs.

The schooner Palinurus, however, was put in commission under command of Lieut. R. Clover, U. S. N., and during the summer was engaged in the survey of Long Island Sound; and the schooner G. M. Bache, under the command of Assistant J. S. Bradford, was engaged in Coast Pilot work.

Commander Bartlett, after commencing the season in command of the steamer Blake, running a line of deep-sea soundings and temperatures from Nantucket to Bermuda, and thence to Cape Hatteras, was compelled to succumb to the great strain upon his system during over four years' command of the vessel, and was relieved October 1, 1882, by Lieut. Commander W. H. Brownson, who had previously been ordered by you to the vessel to become acquainted with the methods of carrying on the work.

Lieut. Commander Brownson's place as commanding officer of the steamer Gedney was filled by the transfer of Lieut. H. B. Mansfield from the command of the steamer Endeavor, and his place in turn was filled by the promotion of Lieut. Hugo Osterhaus, the senior Assistant on board the Endeavor.

After assuming command, Lieut. Commander Brownson, in the Blake, ran a line of deep-sea soundings to the eastward of Nantucket, and then returned to the southern coast of Long Island, continuing the work upon which the party was engaged at the commencement of the fiscal year.

Lieut. P. Garst's time having expired, he was relieved from duty in the Coast Survey on July 2, 1882, and the command of the schooner Earnest was given to Lieut. T. Dix Bolles, U. S. N., transferred from the steamer Hassler.

The various parties remained at work in the northern waters as long as the weather permitted, or until about November 1, when they prepared for the winter season in the southern waters. This time was taken to make some changes in the organization of the parties, necessitated by the expiration of the terms of service of some of the naval officers attached to the Survey.

Lieut. Commander E. B. Thomas' very efficient service, first as commander of the steamer Endeavor and lastly of the steamer Bache, having been completed, he was relieved by the Navy Department November 25, 1882, and the command of the latter vessel assumed, under your instructions, by Lieut. H. B. Mansfield, while the command of the Gedney devolved upon Lieut. E. M. Hughes.

Lieut. H. G. O. Colby, U. S. N., very much to the regret of this office, was, after over two years' service as chief of party in command of the schooner Eagre, withdrawn for regular naval duties and his place taken by Lieut. E. D. F. Heald, U. S. N.

Lieut. Hugo Osterhaus's services were about the same time lost to the Survey by the expiration of his three years' service, and Lieut. John T. Sullivan, U. S. N., having been ordered to the Survey by the Navy Department, was assigned to the command of the steamer Endeavor in his place. The vacancy in the command of the schooner Silliman, made by the transfer of Lieut. E. M. Hughes to the Gedney, was filled by Lieut. F. A. Wilner, the senior Assistant on the Bache.

I will append to this report a complete list of the naval officers on Coast Survey service during the fiscal year, giving the dates of their attachment and detachment, with the names of those officers still on duty in the Survey. Also, a list of the vessels belonging to the work, their tonnage, &c.

During the winter the vessels were engaged in surveys at the following points:

The Blake, in deep-sea soundings, between Bermuda and the Bahamas, and along the outside of the Bahama Banks.

The steamer A. D. Bache, during the earlier part of the season on the west coast of Florida, and later on the east coast.

The steamer Gedney surveyed Galveston inner bar and continued the outside work from Galveston entrance to the eastward.

The steamer Endeavor, in the vicinity of Cape Romain, South Carolina.

The steamer Hitchcock, in charge of Assistant F. W. Perkins, in Sabine Pass and Calcasieu River.

The steamer Barataria, in charge of Assistant C. H. Boyd, in the bayous of Louisiana, to the westward of the Jump.

The schooner Eagre, in the Saint John's River from Jacksonville to the bar.

The schooner Quick, in charge of Subassistant J. Hergesheimer, in the vicinity of Sarasota, Fla.

The schooner Silliman, at Cape Fear entrance, North Carolina, and later in Pamplico Sound.

The schooner Drift, engaged in obtaining current observations off the coast, from Cape Charles to Cape Florida.

The schooner Ready, in charge of Assistant O. H. Tittmann, in Key Biscayne Bay, Fla.

The sloop Steadfast, in charge of Assistant B. A. Colonna, in Indian River, Fla.

On the Pacific coast the steamer Hassler, having returned from Alaska about December 1, was preparing during the winter for a continuation of the important work on that coast as soon as the weather would permit, and sailed about the middle of April.

The steamer McArthur continued the survey of the coast of California from Monterey southward.

The vessels actually at work continued until about May 15, when they were withdrawn to prepare for the summer season.

During the latter part of the fiscal year the following vessels were at work in northern waters:

The Blake, off New York entrance;

The Arago, under command of Lieut. G. C. Hanus, in Delaware Bay;

The Scoresby, in charge of Assistant Charles Hosmer, at Hart and City Islands, Long Island Sound; and

The Palinurus, Lieut. A. V. Wadhams commanding, at Stonington, Conn.

All the other vessels were, at the close of the fiscal year, either laid up or were engaged in active preparation for commencing the summer season's work at an early date after July 1.

The results of the various surveys are given in the detailed reports of the chiefs of parties.

REPAIRS.

The very small appropriation at the disposal of the office in caring for a fleet of twenty-five vessels, with nearly double the number in commission than there have been in previous years, has rendered it only possible to make the most important repairs. The machinery of the larger steamers (Blake, Bache, Gedney, Hassler, and McArthur) alone requires a good share of the $30,000 to keep it in order. Particularly is this the case on the western coast, where this class of work is very expensive.

The schooners, such as the Research, Drift, Palinurus, Ready, Brisk, Quick, &c., being what are known as composite vessels, require to be stripped of their copper at about the end of five years (or the average age at which copper sheathing lasts), so that the iron bolts may be renewed where the fastenings have been loosened and galvanic action going on, yet nearly all the vessels are ten or twelve years old now, and the Silliman is the first one that has been remetaled. This vessel, although one of the class having wooden frames, was found to require new metal before going south last year, and the result proved that in addition to the cost of replacing the metal (a matter of some $1,200 or $1,500) the expense was much increased by the number of bolts that were found corroded. This loosened the planks and the vessel had to be docked several times, stripping a good portion of her copper each time before she was made tight again. In this case, the work being done under contract, the expense of the additional labor was met by the contractors. This action between the copper and the iron having taken place in a wooden vessel much more expense is anticipated in remetaling the vessels with iron frames, where larger masses of iron are exposed to the galvanic action between the two substances.

While the usual allowance of $30,000 for repairs of vessels is sufficient for the ordinary wear and tear of material, these and other causes make it necessary for me to submit for your consideration an additional estimate for the extraordinary exigencies of the service. During the year the steamer Arago has been supplied with new boilers. In taking the old ones out it was found that many sheets of her bottom plating were nearly eaten through, and twenty-one of them, covering a good portion of her bottom, had to be replaced. These extensive repairs have put her iron hull in very good condition, but the expenses ran up to such a sum that little or nothing could be done to the wood-work, which is sadly in need of repairs, and when made the vessel will be in very good condition.

The steamer Blake has had only enough repairs to make her tide over another season, when, it is thought, a considerable amount of money will have to be expended upon her or the vessel put out of commission.

About five years ago the boilers of this vessel were reported as requiring replacing, but an examination made it advisable to put extensive repairs upon them which would carry her through two years' more service. Since that time they have been kept running, until now they have gotten to such a point that it is dangerous to run them except under a low, and not an economical, pressure of steam.

Her upper deck has in a like manner been patched up to await the removal of her boilers, when a good portion of it would have to be replaced anyway, and economy demands that this should be done at the same time. This will be a matter of $10,000 or $12,000, and if required to come out of the general appropriation leaves a very small proportion for the rest of the fleet.

The steamer Bache, in addition to incidental expenses, such as a new boat, new awnings, slight repairs to the machinery before starting south for the survey of the coast of Florida, returned in June requiring new braces and extensive patches on the boiler and other portions of the machinery,

and also a general overhauling. This, through the courtesy of the commandant of the New York navy-yard, has been done for less than any outside contractor would do the work, and it is believed that a better job has been made than otherwise would have been done. The boiler of this vessel is beginning to show its age (over ten years), and within a short time will have to be replaced.

The steamer Hassler, as has already been mentioned, was compelled to have her repairs made in an expensive market on the Pacific coast, and the $5,000 or $6,000 expended upon her has allowed but little more than an extensive overhauling of the boilers, machinery, and hull to fit her for her long season's work in Alaskan waters; and it is thought the end of this season will find her boilers in such a condition as to make it unsafe for further demands to be made upon them.

In renewing the boilers of this vessel there will be required, as in the Blake, a new upper deck. This vessel was built of iron of ½ inch thickness, in 1872, and the question of sheathing her with wood, as was done in the case of the steamer Bache, will soon have to be taken up. Four inches of oak or Oregon fir over this iron would make her a most efficient vessel, of great strength, and much more liable to escape serious injury in grounding (an accident that is very likely to occur to a surveying vessel). The iron bottom now compels docking the vessel once in six months at least, to clear the extensive growth of barnacles, grass, &c.; in fact, after two months the speed of the vessel has been reduced to such an extent by fouling, that economy would demand docking to save the expense of coal wasted. Of course this would be unnecessary with the wooden sheathing covered with metal, and it is thought it would take only a few years to make up the difference in consumption of coal, docking expenses, &c. It would seem very much to the interest of the Government to execute both of these extensive repairs at the same time.

The steamer Gedney has had during the year some general repairs to machinery and hull, new masts, new sails, and two new boats; has been fitted with a distiller for condensing fresh water for the crew, thereby benefiting the sanitary condition of the ship and saving much time usually required in replenishing the tanks. Steam heaters have been fitted throughout the vessel, which proved conducive both to the health of the crew and safety of the ship. This vessel, with the exception of her propeller and shoe, which have gradually become corroded by the galvanic action going on between its iron and the copper of the vessel's bottom, is in very good condition.

The McArthur's repairs have been slight during the year, and with the exception of some improvements to be made to the fittings of the vessel, such as a steam windlass, will probably be slight during the coming year.

The steamer Endeavor has had quite extensive repairs on the machinery, consisting of lining up shaft, new brasses, and new fittings required to an engine of old design and imperfect attachments. The lower part of her hull is in good condition, with the exception of the rudder, which is likely to require replacing at the end of this season. Some repairs may be anticipated upon the hull and rigging also.

The steamer Hitchcock was found to require some general repairs upon preparing for the last winter's work, such as a new stem, a number of new planks, repairs to stern-post, &c. The vessel was fitted out quite inexpensively throughout by Lieutenant Flynne, who, with some old sails belonging to the Brisk, made new ones for this vessel, as well as fitting rigging, &c., by the ship's crew. She is likely to require some slight repairs before taking the field again.

The schooner Eagre, formerly the yacht Mohawk, has had nearly a complete set of new sails during the year, and as far as they are concerned she is in good order, but her hull begins to show signs of weakness. A vessel of her size and build requires all her parts in good condition. Lieutenant Heald reports that on the passage north from the Saint John's River, during a gale of wind, while she showed qualities that her officers and crew were compelled to admire, yet the indications were that some defect existed that could not be seen, since she leaked as much as twenty-four inches a day. Before subjecting her to so severe a strain again, it will be necessary to remove the old copper, calk the vessel, and put new metal on the bottom, and Lieutenant Heald reports that new decks will also be required. This is a matter of $5,000 or $6,000.

Besides these vessels, the steamer Barataria, schooners Earnest, Scoresby, Quick, G. M. Bache, Drift, Palinurus, Ready, and sloop Steadfast have been in commission and required more or less repairs, as indicated in the statement of the disbursing agent of amount of money expended on each vessel. The steamer Barataria is likely to require extensive repairs before again taking the

field. One of the two vessels, Palinurus or Ready, should be entirely remetalled this year, and one the next, until which time they should not be exposed to much outside weather.

The schooner Research, after replacing some rotten planking and fittings, with new sails and equipments, will be ready for such work as she is likely to be called upon for. The Yukon has been fitted out for harbor work only, but can stand the short passages she may have to make.

The following vessels have been laid up during the whole year:

Steamer Fathomer, at Washington. Her machinery is of a peculiar type and could be put in order at a moderate expense, but the hull will require $1,000 to $1,500 to prepare her for inside work.

The schooner Brisk, at New Orleans. In attempting to fit this vessel out for service in the fall of 1882, the estimates came to nearly as much as a new vessel would cost to put her into only fair order. I would recommend that she be sold, as of no furtner use to the Survey. She is not likely to bring more than $200 when the equipments that can be used elsewhere are removed from her.

In addition to these vessels the steam launches belonging to the Survey, fifteen in number, have had more or less repairs. In this connection I desire to state that the service has derived much benefit from the use of four steam launches loaned to it through the chief constructor of the Navy, as well as the facilities that have been constantly extended by the commandants of the several navy-yards for repairing vessels, &c.

HYDROGRAPHIC DIVISION.

The usual routine duties of the office have continued. The aids to navigation, as will be seen by the catalogue recently published, are indicated on the charts to the latest date. This part of the office duties has been under the direction of Lieut. J. E. Pillsbury, U. S. N., who brought to the office on his re-entry into the Survey in July, 1882, an experience in the handling of charts seldom had by one officer, and his system and zeal have enabled the office to keep our charts to the latest dates. I would call your attention to the hearty co-operation of the Light-House Board, through its secretaries, in informing this office at the earliest moment of changes or contemplated changes in aids to navigation. Upon authority being given by the Board to one of the light-house inspectors, in any way relating to aids to navigation, the Naval Secretary sends to this office a chart showing the proposed change or addition, and this office returns at once a fresh copy of the chart sent, in order that the files of the Board may be complete.

The plotting and preparation of the hydrographic sheets from the data sent in by the parties have been carried on in the usual efficient manner by Messrs. E. Willenbucher, W. C. Willenbucher, F. C. Donn, and since his assignment, by Mr. Charles Junken.

The latter, in addition to his regular work referred to in the report from the Drawing Division, was engaged in revising miscellaneous projections, verifying proofs of sailing charts, &c., while the others were employed in making transfers and in the plotting of angles and soundings. I give a synopsis of the hydrography plotted by the Messrs. Willenbucher and by Mr. Donn.

Names.	Number of—				
	Volumes.	Angles.	Soundings.	Miles.	Deep-sea soundings.
E. Willenbucher	70	26,263	132,644	3,839	1,501
W. C. Willenbucher	60	18,087	77,618	3,887½	....
F. C. Donn	65	21,507	80,323	2,007½	....
	195	65,857	290,585	9,734	1,501

Lieut. Richardson Clover, since returning from field-work in January last, has been engaged upon the preparation of the second edition of the "Instructions for Hydrographic Parties," and from him I have received much assistance in the preparation of the plans and specifications for the new steamer Patterson. Passed Assistant Engineer H. N. Stevenson, since his assignment

to Coast Survey duty in March, 1883, has rendered valuable assistance in the steam engineering department of this vessel, preparing the plans for the boilers and engines, with what results the data which have received your approval will show.

Respectfully submitted.

C. M. CHESTER,
Commander, United States Navy, Hydrographic Inspector Coast Survey.

J. E. HILGARD,
Superintendent Coast and Geodetic Survey.

Errata in the report of the Hydrographic Inspector for the fiscal year ending June 30, 1882.

In Coast and Geodetic Survey Report for 1882—

Page 98, line 32, "steamer Endeavor," should be "steamer Gedney."

Page 99, lines 41 and 42, the address "Genl. R. D. Cutts," &c., should be "Prof. J. E. Hilgard, Superintendent Coast and Geodetic Survey."

Page 100, line 28, the name of "J. C. Fremont, jr.," should be omitted from the list of lieutenants.

Officers of the Navy on Coast Survey service during the fiscal year ending June 30, 1883.

Name and rank.	Date of attachment.	Remarks.
COMMANDERS.		
J. R. Bartlett	Oct. 23, 1878	Detached November 1, 1882.
C. M. Chester	Oct. 2, 1877	Still in service.
LIEUTENANT-COMMANDERS.		
W. H. Brownson	Aug. 11, 1881	Still in service.
H. E. Nichols	Jan. 22, 1879	Do.
E. B. Thomas	Oct. 8, 1879	Detached November 25, 1882.
LIEUTENANTS.		
W. T. Swinburne	May 5, 1879	Detached May 24, 1883.
John T. Sullivan	Nov. 21, 1882	Still in service.
H. B. Mansfield	Feb. 28, 1881	Do.
E. D. F. Heald	Mar. 23, 1882	Do.
Richardson Clover	July 26, 1881	Do.
H. G. O. Colby	Oct. 7, 1880	Detached December 20, 1882.
E. D. Taussig	Apr. 30, 1883	Still in service.
J. E. Pillsbury	July 13, 1882	Do.
A. V. Wadhams	Apr. 18, 1883	Do.
G. Blocklinger	Jan. 30, 1883	Do.
Perry Garst	Aug. 29, 1879	Detached July 17, 1882.
T. Dix Bolles	Apr. 5, 1881	Still in service.
E. M. Hughes	June 22, 1882	Do.
Hugo Osterhaus	July 31, 1879	Detached November 25, 1882.
F. M. Crosby	Nov. 17, 1882	Still in service.
G. W. Mentz	Aug. 19, 1879	Detached November 23, 1882.
J. B. Milton	Sept. 6, 1882	Still in service.
G. C. Hanus	Mar. 20.	Do.
W. B. Elliott	Jan. 25, 1879	Do.
F. H. Lefavor	Sept. 6, 1882	Do.
J. C. Fremont, jr	May 21, 1881	Do.
F. A. Wilner	Nov. —, 1880	Do.
Harry Morrell	Dec. 8, 1879	Detached June 14, 1883.
H. F. Reich	May 1, 1879	Detached October 16, 1882.
Lucian Flynne	Mar. 7, 1881	Still in service.
W. B. Cutter	Mar. 29, 1883	Do.
C. Mc. R. Winslow	Aug. 16, 1881	Do.
M. L. Wood	Sept. 19, 1878	Detached July 25, 1882.
David Daniels	Apr. 21, 1882	Still in service.
ENSIGNS.		
F. W. Coffin	May 24, 1880	Detached February 22, 1883.
W. B. Caperton	Nov. 11, 1880	Still in service.
ENSIGNS—Continued.		
W. H. Allen	June 27, 1879	Detached June 27, 1883.
E. M. Katz	Nov. 22, 1881	Still in service.
H. T. Mayo	May 1, 1879	Detached July 13, 1882.
John T. Newton	Aug. 19, 1882	Still in service.
C. F. Pond	May 1, 1879	Detached March 12, 1883.
L. K. Reynolds	July 13, 1882	Detached January 18, 1883.
E. N. Fisher	Feb. 10, 1882	Still in service.
T. D. Griffin	May 20, 1883	Do.
F. H. Sherman	Oct. 31, 1882	Do.
H. M. Weitzel	Feb. 10, 1882	Do.
O. G. Dodge	May 10, 1881	Do.
J. M. Orchard	Feb. 10, 1882	Do.
J. N. Jordan	Jan. 25, 1881	Do.
J. P. Parker	Mar. 5, 1883	Do.
H. C. Wakenshaw	June 23, 1882	Do.
A. F. Fechteler	June 24, 1882	Do.
T. M. Brumby	Dec. 21, 1882	Do.
S. E. Woodworth	June 9, 1882	Detached April 19, 1883.
Alfred Jeffreys	July 17, 1882	Still in service.
W. V. Bronaugh	Aug. 12, 1881	Do.
F. M. Bostwick	Sept. 28, 1881	Do.
W. M. Constant	June 5, 1882	Detached November 4, 1882.
A. L. Hall	May 1, 1883	Still in service.
J. H. Fillmore	Jan. 24, 1883	Do.
C. S. McClain	Apr. 14, 1882	Do.
Harry S. Knapp	July 6, 1882	Do.
P. P. Bibb	Nov. 30, 1882	Do.
W. C. Canfield	Sept. 26, 1882	Do.
W. P. White	Feb. 10, 1883	Do.
J. H. Hetherington	June 19, 1883	Do.
R. P. Schwerin	May 3, 1883	Do.
J. A. Dougherty	Oct. 7, 1882	Detached June 26, 1883.
Harry Phelps	June 30, 1882	Still in service.
F. W. Kellogg	Aug. 23, 1882	Do.
A. A. Ackerman	June 30, 1882	Detached November 30, 1882.
William Truxtun	July 3, 1882	Still in service.
L. S. Van Duser	Aug. 22, 1882	Do.
E. Simpson, jr	Oct. 21, 1882	Do.
E. F. Leiper	Apr. 26, 1883	Do.
J. C. Drake	Dec. 18, 1882	Detached June 21, 1883.
T. G. Dewey	June 19, 1883	Still in service.

Officers of the Navy on Coast Survey service during the fiscal year ending June 30, 1883—Continued.

Name and rank.	Date of attachment.	Remarks.	Name and rank.	Date of attachment.	Remarks.
ENSIGNS—Continued.			PAYMASTER.		
George R. French	May 4, 1883	Still in service.	W. J. Thomson	Dec. 18, 1880	Still in service.
M. C. Gorgas	Oct. 26, 1882	Do.	PASSED ASSISTANT ENGINEERS.		
Guy M. Brown	Dec. 26, 1882	Do.			
PASSED ASSISTANT SURGEONS.			C. H. Greenleaf	Aug. 19, 1880	Detached May 28, 1883.
			John F. Bingham	Mar. 4, 1882	Detached February 24, 1883.
Ezra Y. Derr	Sept. 7, 1881	Still in service.	H. Main	May 29, 1883	Still in service.
D. O. Lewis	Nov. 16, 1881	Detached June 6, 1883.	H. N. Stevenson	Mar. 10, 1883	Do.
R. M. McCarty	Apr. 8, 1881	Still in service.	G. H. Kearney	Oct. 5, 1881	Do.
S. W. Battle	Nov. 17, 1881	Do.	R. W. Galt	Nov. 26, 1879	Do.
H. C. Beyer	May 31, 1882	Do.	Edgar T. Warburton	Feb. 24, 1883	Do.
F. C. Dale	June 6, 1883	Do.	R. I. Reid	June 9, 1882	Do.

SUMMARY.

Commanders	2
Lieutenant-commanders	3
Lieutenants	29
Ensigns	46
Passed assistant surgeons	6
Paymaster	1
Passed assistant engineers	8

Names of vessels, their tonnage, &c., in the service of the Coast Survey during the fiscal year ending June 30, 1883.

No.	Name.	Tonnage.	Complement of— Officers.	Men.
1	Steamer Blake	218	8	36
2	Steamer A. D. Bache	186	7	33
3	Steamer Gedney	133	7	29
4	Steamer Hassler	243	9	34
5	Steamer McArthur	112	7	29
6	Steamer Arago	38	3	15
7	Steamer Endeavor	105	4	17
8	Steamer Barataria	50	1	15
9	Steamer Hitchcock	83	3	15
10	Steamer Fathomer (laid up)	50		
1	Schooner G. N. Bache	46	2	10
2	Schooner Eagre	202	4	18
3	Schooner Silliman	72	3	14
4	Schooner Drift	87	4	14
5	Schooner Earnest	80	2	12
6	Schooner Palinurus	76	3	14
7	Schooner Ready	80	3	14
8	Schooner Scoresby	72	2	12
9	Schooner Quick	38	2	14
10	Schooner Yukon (laid up)	78		
11	Schooner Brisk (laid up)	38		
12	Schooner Research	76	3	14
1	Sloop Steadfast	39	1	12
2	Sloop Kincheloe (laid up)	30		
1	Barge Beauty (civilian party)	28		

RECAPITULATION.

Whole number of vessels:	
Steamers	10
Schooners	12
Sloops	2
Barge	1
Total	25
Number of vessels in active service	21

APPENDIX No. 6.

DESCRIPTIVE CATALOGUE OF PUBLICATIONS RELATING TO THE COAST AND GEODETIC SURVEY AND TO STANDARD MEASURES.

Compiled by EDWARD GOODFELLOW, Assistant.

CLASSIFICATION.

I.—Annual Reports and other documents of the United States Coast and Geodetic Survey and Standard Weights and Measures. 1807 to 1881.
II.—General Index of Scientific Papers contained in the Annual Reports of the United States Coast and Geodetic Survey from 1845 to 1880, inclusive. (Published as Appendix No. 6 to the Report for 1881.)
III.—List of Tide-Tables from the date of earliest publication in the Survey to the year 1881.
IV.—Catalogue of Coast Pilots for the Atlantic and Pacific Coasts of the United States from the date of earliest publication to the year 1881.
V.—Chart Catalogues. Catalogues of Maps and Charts published by the Survey between the years 1835 and 1881.
VI.—Notices to Mariners.
VII.—Special publications.

I.

ANNUAL REPORTS AND OTHER DOCUMENTS OF THE U. S. COAST AND GEODETIC SURVEY AND STANDARD WEIGHTS AND MEASURES. 1807 *TO* 1881.

U. S. COAST SURVEY.

REPORTS AND OTHER DOCUMENTS.

Date.	Subject.	Number of pages and size.
1807.		
February 10	An act to provide for surveying the coast of the United States	
March 25	Circular letter addressed by the Secretary of the Treasury to F. R. Hassler, requesting that he would suggest the outlines of a plan for the survey of the coast—such as would unite correctness and practicability. [Transactions American Philosophical Society. Vol. II. New series.]	2, quarto.
April 2	Letter of Mr. Hassler to the Secretary of the Treasury, transmitting a plan for putting into operation the survey of the coast of the United States. [Transactions American Philosophical Society. Vol. II. New series.]	13, quarto.
1816.		
May 15	Communication made to the Secretary of the Treasury by F. R. Hassler, on the measu es necessary to be taken to put into immediate operation such portions of the work as could be undertaken during the coming season.	
June 11, 18; July 12; August 3, 18.	Correspondence with the Treasury Department and articles of engagement between the Treasury Department of the United States and F. R. Hassler, relative to the survey of the coast of the United States.	9, octavo.
November 23, 30	First Report of F. R. Hassler, Superintendent of the Survey of the Coast of the United States, to the Secretary of the Treasury upon the progress of the work.	3, octavo.
1818.		
April 9	Letter of Mr. Hassler to the Secretary of the Treasury, discussing the objects of the survey of the coast and reviewing the progress of the work.	5, octavo.

REPORTS AND OTHER DOCUMENTS—Continued.

Date.	Subject.	Number of pages and size.
1818.		
April 22	Letter of F. R. Hassler to the Secretary of the Treasury, in regard to the repeal of the act *authorizing the survey of the coast and making statement of arrangements desirable for the preservation of the work already accomplished.	2, octavo.
April 27	Communication by Mr. Hassler to the Secretary of War, respecting the transfer of the work of the Coast Survey to the War Department; also, a statement of the "Principal dates of the survey of the coast."	13, octavo.
1832.		
July 10	An act to carry into effect the act to provide for a survey of the coast of the United States. Approved July 10, 1832.	
July	Letter of F. R. Hassler to the Secretary of the Treasury, presenting the principles and views of his plan of operation for the survey of the coast as adopted in 1807.	9, octavo.
August 6	Upon the articles of agreement between the Treasury Department of the United States and F. R. Hassler, relative to the survey of the coast of the United States.	2, octavo.
August 9	Letter of the Secretary of the Treasury to F. R. Hassler, appointing him to make, under the direction of the Treasury Department, the survey of the coast as provided for by the acts of February 10, 1807, and July 10, 1832.	1, octavo.
August 9	Circular letter from the Secretary of the Treasury, requesting all owners and occupiers of lands over which Mr. Hassler and his assistants may have occasion to pass in the performance of their public duties to permit them freely to pass over and remain on the same as long as may be necessary in executing the work of the survey of the coast.	
1833.		
December 1	Letter of Mr. Hassler to the Secretary of the Treasury, reporting the progress made in the work of the survey of the coast.	2, octavo.
1834.		
March 12	Letter from the Secretary of the Treasury to Mr. Hassler, informing him that, with the approval of the President, the superintendence of the Coast Survey has been transferred from the Treasury to the Navy Department.	
March 14 to April 14	Correspondence of Mr. Hassler with the Secretary of the Navy, relative to the transfer of the Coast Survey to the Navy Department. With a "Continuation of the principal facts and dates relating to the Coast Survey, after the interruption of the work in 1818."	19, octavo
May 17	Report by F. R. Hassler to the Secretary of the Navy upon the "Works executed for the survey of the coast of the United States, upon the law of 1832, and their junction with the works made in 1817 by and under the direction of F. R. Hassler."	14, octavo
November 11	Report of F. R. Hassler as Superintendent of the Survey of the Coast, additional to that dated May 17, containing an account of the progress of that work during the summer and until November of 1834.	7, octavo.
1835.		
February 17	Statement by F. R. Hassler of the "Considerations which make an increase of the appropriation proposed for the survey of the coast for the present year desirable and advantageous."	2, octavo.
May 8	Third Report of F. R. Hassler, as Superintendent of the Survey of the Coast, upon the progress of that work from November, 1834, to May, 1835.	4, octavo.
November 22	Fourth Report of F. R. Hassler, as Superintendent of the Survey of the Coast, upon the operations performed in that work between the months of May and December, 1835. With an estimate of the appropriation required for the next year's work.	6, octavo.
1836.		
March 8	Statement made by Mr. Hassler to the Secretary of the Navy, of reasons for placing the Coast Survey in the Treasury Department, and neither in the War nor Navy Departments.	2, octavo.
March 25-27	The direction of the Coast Survey transferred from the Navy Department to the Treasury Department. See letters of March 25 from the Secretary of the Navy to Mr. Hassler, and of March 27 from Mr. Hassler to the Secretary of the Treasury.	15, octavo.
April 13, 18, 30	Reports from the Secretary of the Treasury and the Chief of the Topographical Bureau, United States Army, upon the salaries of the Superintendent of the Coast Survey and his assistants. With remarks by Mr. Hassler in relation thereto.	15, octavo.
November 19	Fifth Report of F. R. Hassler, as Superintendent of the Coast Survey, * * * exhibiting the operations performed in 1836.	5, octavo.

*An act to repeal part of the act entitled "An act to provide for surveying the coasts of the United States." Approved April 14, 1818.

UNITED STATES COAST SURVEY AND STANDARD WEIGHTS AND MEASURES.

ANNUAL REPORTS.

FERDINAND R. HASSLER, *Superintendent.*

Period of report.	Subject.	Number of pages and size.	Designation as a public document.
1837	United States Coast Survey	5, octavo	Twenty-fifth Congress, second session, No. 79, Senate.
	Weights and Measures	11, octavo	Do.
1838	United States Coast Survey	6, octavo	Twenty-fifth Congress, third session, No. 4, Senate.
	Weights and Measures	1, octavo	Do.
1839	United States Coast Survey	6, octavo	Twenty-sixth Congress, first session, No. 15, Senate.
	Weights and Measures	2, octavo	Do.
1840	United States Coast Survey	7, octavo	Twenty-sixth Congress, second session, No. 14, House of Representatives–Treasury Department.
	Weights and Measures	1, octavo	Do.
Dec., 1841		18, octavo	Twenty-seventh Congress, second session, No. 28, House of Representatives–Treasury Department.
Jan., 1842*		8, octavo	Twenty-seventh Congress, second session, No. 57, House of Representatives–Treasury Department.
Dec., 1842*		5, octavo	Twenty-seventh Congress, third session, No. 11, Senate.
Jan., 1843†		103, octavo	Twenty-seventh Congress, third session, No. 43, House of Representatives.
Feb., 1843†		93, octavo	Twenty-seventh Congress, third session, No. 170, House of Representatives.
Nov., 1843‡ and Jan., 1844.		8, octavo	Twenty-eighth Congress, first session, No. 97, House o Representatives–Treasury Department.

NOTE.—The reports and other papers named in the preceding list, beginning with June, 1816, have been collected and bound together in two octavo volumes, which are deposited in the Coast Survey archives. The titles of these volumes are: "Principal Documents relating to the Survey of the Coast of the United States since 1816. Published by F. R. Hassler, Superintendent of the Survey, 1834;" and "Coast Survey Weight and Measure Documents, 1832 to 1843."

* Report in regard to progress and expenditures.

† Reports of select committee of the House of Representatives upon progress and expenditure in the Coast Survey.

‡ Last report of F. R. Hassler, as Superintendent of the Coast Survey, transmitted January 29, 1844, by the Secretary of the Treasury to Congress.

UNITED STATES COAST SURVEY.

ANNUAL REPORTS.

ALEXANDER DALLAS BACHE, *Superintendent.*

Report for year ending—	Number of pages and size.	Number of appendices.	Number of illustrations.	Designation as a public document.
Nov., 1844	22, octavo		4	Twenty-eighth Congress, second session, No. 25, House of Representatives–Treasury Department.
1845	44, octavo	4	3	Twenty-ninth Congress, first session, No. 38, House of Representatives–Treasury Department.
1846	74, octavo	11	9	Twenty-ninth Congress, second session, No. 6, House of Representatives–Treasury Department.
Oct., 1847	88, octavo	18	11	Thirtieth Congress, first session, Senate, Executive No. 6.
Nov., 1848	120, octavo	19	16	Thirtieth Congress, second session, Senate, Executive No. 1.
1849	98, octavo	20	16	Thirty-first Congress, first session, Senate, Executive No. 5.
1850	134, octavo	37	27	Thirty-first Congress, second session, House of Representatives, Executive Document No. 12.
1851	559, octavo	57	58	Thirty-second Congress, first session, Senate, Executive Document No. 3.
1852	173, quarto	52	37	Thirty-second Congress, second session, House of Representatives, Executive No. 64.
Oct., 1853	186, quarto	58	54	Thirty-third Congress, first session, Senate, Executive No. 14.
1854	288, quarto	73	58	Thirty-third Congress, second session, House of Representatives, Executive Document No. 20.
1855	420, quarto	86	60	Thirty-fourth Congress, first session, House of Representatives, Executive Document No. 6.
1856	358, quarto	86	67	Thirty-fourth Congress, third session, Senate, Executive Document No. 12.

ANNUAL REPORTS—Continued.

Report for year ending—	Number of pages and size.	Number of appendices.	Number of illustrations.	Designation as a public document.
Oct., 1857	448, quarto	65	72	Thirty-fifth Congress, first session, Senate, Executive Document No. 33.
1858	464, quarto	50	40	Thirty-fifth Congress, second session, Senate, Executive Document No. 14.
1859	371, quarto	43	40	Thirty-sixth Congress, first session, House of Representatives, Executive Document No. 41.
1860	409, quarto	45	30	Thirty-sixth Congress, second session, Senate, Executive Document.
1861	270, quarto	34	31	Thirty-seventh Congress, second session, Senate, Executive Document.
1862	434, quarto	40	41	Thirty-seventh Congress, third session, House of Representatives, Executive Document No. 70.
1863	218, quarto	29	30	Thirty-eighth Congress, first session, Senate, Executive Document.
1864	315, quarto	24	39	Thirty-eighth Congress, second session, Senate.

JULIUS E. HILGARD, *Acting Superintendent.*

Oct., 1865	231, quarto	22	32	Thirty-ninth Congress, first session, House of Representatives, Executive Document No. 75.
1866	140, quarto	20	30	Thirty-ninth Congress, second session, House of Representatives, Executive Document No. 87.

BENJAMIN PEIRCE, *Superintendent.*

Oct., 1867	334, quarto	20	28	Fortieth Congress, second session, House of Representatives, Executive Document No. 275.
1868	277, quarto	15	29	Fortieth Congress, third session, House of Representatives, Executive Document No. 71.
1869	259, quarto	15	28	Forty-first Congress, second session, House of Representatives, Executive Document No. 206.
1870	232, quarto	22	28	Forty-first Congress, third session, House of Representatives, Executive Document No. 112.
1871	219, quarto	18	36	Forty-second Congress, second session, House of Representatives, Executive Document No. 121.
1872	267, quarto	18	24	Forty-second Congress, third session, House of Representatives, Executive Document No. 240.
1873	180, quarto	15	18	Forty-third Congress, first session, House of Representatives, Executive Document No. 133.

CARLILE P. PATTERSON, *Superintendent.*

June, 1874	242, quarto	18	24	Forty-third Congress, second session, House of Representatives, Executive Document No. 100.
1875	412, quarto	20	37	Forty-fourth Congress, first session, House of Representatives, Executive Document No. 81.
1876	416, quarto	23	37	Forty-fourth Congress, second session, Senate, Executive Document No. 37.
1877	192, quarto	15	25	Forty-fifth Congress, second session, Senate, Executive Document No. 12.

UNITED STATES COAST AND GEODETIC SURVEY.

June, 1878	304, quarto	11	39	
1879	213, quarto	16	53	
1880	419, quarto	19	84	

NOTE.—At the date of publication of this Descriptive Catalogue the reports for the years ending June 30, 1881 and 1882, J. E. HILGARD Superintendent, have been published.

UNITED STATES STANDARD WEIGHTS AND MEASURES.

REPORTS AND OTHER DOCUMENTS.

Date.	Subject.	Number of pages and size.
1831.		
Apr. 30, June 18	Letters of the Secretary of the Treasury to F. R. Hassler, Superintendent United States Standard Weights and Measures, respecting permanent standards of weights and measures for the Treasury Department; the manufacture of weights and measures for all the custom-houses in the United States, and the adoption of units of weight and of capacity.	2, octavo.
1832.		
Mar. 5	An enumeration of the objects and statements desirable to form a collection of standard weights and measures of foreign countries for the Department of State of the United States.	3, octavo.
1833.		
Jan. 27 and June 20	Report made by Ferdinand Rodolph Hassler to the Treasury Department upon a comparison of weights and measures as used at the several custom-houses of the United States; also a general report upon comparisons of weights and measures, of length and capacity, in compliance with a resolution of the Senate of May 29, 1830, with four illustrations. [Document No. 299, House of Representatives, Twenty-second Congress, first session.]	122, octavo.
1834.		
July and Aug., and 1835. Jan. and Feb.	Correspondence with the Secretary of the Treasury, and reports of progress in the construction of standard weights and measures. F. R. Hassler, Superintendent.	20, octavo.
1836.		
May 13, 18	Correspondence with the Secretary of the Treasury in relation to the construction of standard weights for the United States Mint at Philadelphia.	2, octavo.
June 16	Letter of the Secretary of the Treasury to F. R. Hassler, Superintendent of Weights and Measures, inclosing copy of a joint resolution of Congress in regard to the preparation of complete sets of standard weights and measures for each of the States of the Union.	....
June 17	Reply of Mr. Hassler to the Secretary	2, octavo.
Nov. 19	Report of progress in the construction of standard weights and measures, by F. R. Hassler, Superintendent. [This report is combined with that of the Coast Survey.]	2, octavo.
1837.		
Nov. 18	Report by F. R. Hassler, Superintendent Weights and Measures, upon the establishment of the system of ounce-weights for the mints of the United States. [Above forms part of Senate Document 79, Twenty-fifth Congress, second session.]	10, octavo.
1838.		
June 26	Report to the Treasury Department of the United States upon the construction and completion of the standards of weight for all the States of the Union. [Document 154, House of Representatives, Twenty-fifth Congress, second session.]	6, octavo.
Nov. 14	Seventh report of F. R. Hassler, as superintendent of the construction of standards of weights and measures. [Part of Senate Document 4, Twenty-fifth Congress, third session.]	1, octavo.
1839.		
Nov. 16	Upon the construction of the standards of weights and measures [Part of Senate Document 15, Twenty-sixth Congress, first session.]	2, octavo.
1840.		
July 10	Report upon the completion of the standard yard measures for the respective States. By F. R. Hassler, Superintendent of Weights and Measures. [Document No. 261, House of Representatives, Twenty-sixth Congress, first session.]	6, octavo.
Nov. 17	Upon the construction of standard weights and measures [Part of Document 14, House of Representatives, Twenty-sixth Congress, second session.]	1, octavo.
1841.		
June 22	Report upon the completion of the standard ounce-weights for all the States of the Union. By F. R. Hassler, Superintendent of Weights and Measures. [Document No. 33, House of Representatives, Twenty-seventh Congress, first session.]	4, octavo.
1842.		
Apr. 5	Report upon the construction of standards of liquid capacity measures, with descriptions of the apparatus devised for standarding, tables of last weighings, and ultimate results of adjustment. With 3 illustrations. [Senate Document No. 225, Twenty-seventh Congress, second session.]	26, octavo.
June 29	Report by F. R. Hassler upon the works of the establishment of uniform weights and measures for the United States, made upon a call from the select committee of the House of Representatives. [Coast Survey and Weight and Measure Documents, 1832–1843. *Volume in Coast Survey Library.]	17, octavo.

* In this volume have been collected the reports and other papers named in the preceding list.

REPORTS AND OTHER DOCUMENTS—Continued.

Date.	Subject.	Number of pages and size.
1843 and 1844.		
Nov. 12, 1843, and Jan. 30, 1844.	Report of F. R. Hassler, as superintendent of the construction of standards of weight and measure upon the progress of the works in the construction of standards since December, 1842. Report transmitted to Congress by the Secretary of the Treasury after the death of Mr. Hassler, together with a tabular statement of the work executed for the system of uniform standards for the United States from the beginning of the year 1836 to June, 1842, with their state at that epoch, and the additions made until November, 1843. Six illustrations. [Document No. 94, House of Representatives, Twenty-eighth Congress, first session.]	31, octavo.
1845.		
Feb. 26, 27	Report of Alexander Dallas Bache, Superintendent, on the construction of standard weights, measures, and balances, for the year 1844. [Senate Document 149, Twenty-eighth Congress, second session.]	32, octavo.
1846.		
Apr. 25, Aug. 7	Report upon the progress made in the construction of standard weights, measures, and balances, in the year 1845, under the superintendence of A. D. Bache. [Senate Document 483, Twenty-ninth Congress, first session.]	23, octavo.
1848.		
July 30, Aug. 12	Report to the Treasury Department, by A. D. Bache, on the progress of the work of constructing standards of weights and measures, and balances, in the years 1846 and 1847. Four illustrations. [Senate Executive No. 73, Thirtieth Congress, first session.]	29, octavo.
1851.		
Feb. 7, 10	Letter from A. D. Bache, Superintendent of Weights and Measures, communicating a report of the computation of a manual of tables to be used with the hydrometers recently adopted in the United States custom-houses. With six illustrations. [Senate Executive Document 28, Thirty-first Congress, second session.]	168, octavo.
1856.		
Dec. 31	Report to the Treasury Department of progress made under the superintendence of Alexander D. Bache, in the construction and distribution of standards of weights and measures, and supply of hydrometers to custom-houses; also of balances made and distributed to the States, and the laws severally enacted therein relative to standard weights and measures from the 1st of January, 1848, to the 31st of December, 1856. Six illustrations. [Senate Executive Document 27, Thirty-fourth Congress, third session.]	218, octavo.
1869.		
November 15	Report by Benjamin Peirce, Superintendent of Standard Weights and Measures, to the Secretary of the Treasury, upon the progress made in the construction of metric standards of length, weight, and capacity, in pursuance of a joint resolution of Congress of July 27, 1866.	4, octavo.
1876.		
March 1	Papers relating to metric standards distributed to the States of the Union under a joint resolution of Congress of July 27, 1866, including a description of the metric standards, with directions for their use, by J. E. Hilgard, inspector United States standard weights and measures.	6, octavo.
1876.	The relation of the lawful standards of measure of the United States to those of Great Britain and France; J. E. Hilgard. (Published as Appendix No. 22 to United States Coast Survey Report for 1876.)	5, quarto.
1877.	Comparison of American and British standard yards; J. E. Hilgard. (Published as Appendix No. 12 to United States Coast Survey Report for 1877.)	33, quarto.
1878.		
March 21, 23, 28	Letters of C. P. Patterson, Superintendent Coast Survey, and of J. E. Hilgard, Assistant Coast Survey and Inspector United States Standard Weights and Measures, in relation to the proposition for making the use of the metrical system of weights and measures obligatory in all governmental and individual transactions, embodied, with other statements, in a communication from the Secretary of the Treasury, in response to a resolution of the House of Representatives. [Executive Document No. 71, House of Representatives, Forty-fifth Congress, second session.]	7, octavo. 37, octavo.
May 8, 18	Statement of J. E. Hilgard, inspector United States standard weights and measures, before the Committee on Coinage, Weights, and Measures of the House of Representatives, concerning the standard weights and measures of the United States. [Mis. Doc. No. 61, House of Representatives, Forty-fifth Congress, second session.]	12, octavo.

II.

GENERAL INDEX OF SCIENTIFIC PAPERS CONTAINED IN THE ANNUAL REPORTS OF THE UNITED STATES COAST AND GEODETIC SURVEY FROM 1845 TO 1880 INCLUSIVE.

The General Index referred to in this title was published as Appendix No. 6 to the Report for 1881.

A large edition of this Appendix having been printed separately from the report, copies of it will be available for distribution for some years to come. It has not been deemed advisable therefore to reprint it here. In the pages immediately following is given a list, properly classified, of Appendices to the Reports for the years 1881, 1882, and 1883.

CLASSIFIED INDEX OF APPENDICES TO THE REPORTS FOR 1881, 1882, 1883.—SUBJECTS:

GEODESY:—Gravity; Base Lines and Standards of Length; Triangulation and Instruments; Time.
HYPSOMETRY:—Spirit-leveling.
SURVEYING:—Topography; Hydrography.
PHYSICAL HYDROGRAPHY:—Tides, Currents, and Winds; Deep-sea Soundings and Temperatures.
TERRESTRIAL MAGNETISM.
ASTRONOMY.
SPECIAL.
STATISTICS.

GEODESY.

GRAVITY.

Year.	Appendix.	Pages.	Subject and author.
1881	14	359–441	On the flexure of pendulum supports. By C. S. Peirce, Assistant.
1881	15	442–456	On the deduction of the ellipticity of the earth, from pendulum experiments. By C. S. Peirce, Assistant.
1881	16	457–460	On a method of observing the coincidence of vibrations of two pendulums. By C. S. Peirce, Assistant.
1881	17	461–463	On the value of gravity at Paris. By C. S. Peirce, Assistant.
1882	22	503–516	Report of a conference on gravity determinations, held at Washington, D. C., in May, 1882.
1883	17	......	Determinations of gravity and other observations made in connection with the Solar Eclipse Expedition, May, 1883, to Caroline Island. A report by E. D. Preston.
1883	19	......	Determinations of gravity at Alleghany, Ebensburgh, and York, Pa. By C. S. Peirce, Assistant.

BASE-LINES AND STANDARDS OF LENGTH.

Year.	Appendix.	Pages.	Subject and author.
1881	12	354–356	On the length of a nautical mile. By J. E. Hilgard, Superintendent Coast and Geodetic Survey.
1881	13	357–358	On a method of readily transferring the underground mark at a base monument. By O. H. Tittmann, Assistant.
1882	7	107–138	Description and construction of a new compensation base apparatus, with a determination of the length of two five-meter standard bars. By C. A. Schott, Assistant.
1882	8	139–149	Report of the measurement of the Yolo base, Cal. George Davidson, Assistant.
1883	11	......	Results for the length of the primary base line in Yolo County, Cal. Measurement in 1881 by George Davidson, Assistant. Computation and discussion of results by Charles A. Schott, Assistant.

TRIANGULATION AND INSTRUMENTS.

Year.	Appendix.	Pages.	Subject and author.
1882	9	151–197	Field-work of the triangulation, third edition; R. D. Cutts, Assistant.
1882	10	199–208	On the construction of observing tripods and scaffolds. C. O. Boutelle, Assistant.

TIME.

Year.	Appendix.	Pages.	Subject and author.
1883	18	......	Field catalogue of 1278 time and circumpolar stars; mean places for 1885.0. By George Davidson, Assistant.

HYPSOMETRY.

Year.	Appendix.	Pages.	Subject and author.
1881	10	225–268	Meteorological researches, Part III. Barometric hypsometry, and reduction of the barometer to sea-level. William Ferrel.
1883	12	....	Discussion of results for atmospheric refraction and of comparative hypsometric measures, taken at Mount Diablo and Martinez, Cal., in 1880. Observations by George Davidson, Assistant. Discussion by C. A. Schott, Assistant.

SPIRIT-LEVELING.

Year.	Appendix.	Pages.	Subject and author.
1882	11	209, 517–556	Results of the transcontinental line of geodetic leveling near the parallel of 39°, executed by Andrew Braid, Assistant, Coast and Geodetic Survey. Part I.—From Sandy Hook, N. J., to Saint Louis, Mo. C. A. Schott, Assistant.

SURVEYING.

TOPOGRAPHY.

Year.	Appendix.	Pages.	Subject and author.
1881	7	124–125	Type forms of topography, Columbia River. By E. Hergesheimer, Assistant.
1883	14	....	Report upon standard topographical drawings (first and second series). By E. Hergesheimer Assistant.

HYDROGRAPHY.

Year.	Appendix.	Pages.	Subject and author.
1883	7	....	Table of depths for harbors on the coasts of the United States.

PHYSICAL HYDROGRAPHY.

Year.	Appendix.	Pages.	Subject and author.
1881	11	269–353	Report on the oyster beds of the James River, Virginia, and Tangier and Pocomoke Sounds, Maryland and Virginia. By Lieut. Francis Winslow, U. S. N., Assistant, Coast and Geodetic Survey.
1882	15	427–432	Comparison of the survey of the Delaware River in 1819 with more recent surveys. H. L. Marindin, Assistant.
1882	16	433–436	Study of the effect of river bends in the Lower Mississippi. Henry Mitchell, Assistant.
1883	8	....	The Estuary of the Delaware. A report by Henry Mitchell, Assistant.

TIDES, CURRENTS, AND WINDS.

Year.	Appendix.	Pages.	Subject and author.
1881	18	464–469	New rule for tides in Delaware Bay. By Henry Mitchell, Assistant.
1882	17	437–450	Discussion of the tides of the Pacific coast of the United States. By William Ferrel.
1883	9	....	Report on the harmonic analysis of the tides of Sandy Hook. By William Ferrel.
1883	10	....	Description of a maxima and minima tide-predicting machine. By William Ferrel.

DEEP-SEA SOUNDINGS AND TEMPERATURES.

Year.	Appendix.	Pages.	Subject and author.
1882	18	451–457	Report on the Siemens electrical deep-sea thermometer. By Commander J. R. Bartlett, U. S. N., Assistant. (With a description of the apparatus by Werner Suess.)
1882	19	459–461	Recent deep-sea soundings off the Atlantic Coast of the United States. By Lieut. J. E. Pillsbury, U. S. N., Assistant.

TERRESTRIAL MAGNETISM.

Year.	Appendix.	Pages.	Subject and author.
1881	8	126–158	Terrestrial magnetism; directions for magnetic observations with portable instruments. By C. A. Schott, Assistant.
1881	9	159–224	Terrestrial magnetism; collection of results for declination, dip, and intensity, from observations made by the United States Coast and Geodetic Survey between 1833 and 1882. By C. A. Schott, Assistant.
1882	12	211–276	Secular variation of the magnetic declination in the United States and at some foreign stations. C. A. Schott, Assistant.
1882	13	277–328	Distribution of the magnetic declination in the United States at the epoch 1885.0. C. A. Schott, Assistant.
1882	14	329–426	Records and results of magnetic observations made at the charge of the "Bache Fund" of the National Academy of Sciences, 1871 to 1876. Under the direction of J. E. Hilgard, M. N. A. S.
1883	13	....	Discussion, by C. A. Schott, Assistant, of magnetic observations made at the United States polar station at Ooglaamie, Alaska.

ASTRONOMY.

Year.	Appendix.	Pages.	Subject and author.
1882	20	463-468	The total solar eclipse of January 11, 1880, as observed at Santa Lucia, Cal. By George Davidson, Assistant.
1882	21	469-502	A new reduction of La Caille's observations of fundamental stars in the southern heavens, 1749-1757. By C. A. Powalky.
1883	15	....	The transit of Mercury of November 7, 1881, as observed at Yolo base, Cal. By George Davidson and J. J. Gilbert, Assistants.
1883	16	....	Observations of the transit of Venus of December 6, 1882, at Washington, D. C.; at Tepusquet Station, Cal.; and at Lehmann's Ranch, Nev.

SPECIAL.

Year.	Appendix.	Pages.	Subject and author.
1882	24	559-563	Tribute to the memory of Carlile P. Patterson, Superintendent of the Coast and Geodetic Survey from 1874 to 1881.

STATISTICS.

Year.	Appendix.	Pages.	Subject and author.
1881	1	67-72	Distribution of surveying parties upon the Atlantic, Gulf of Mexico, and Pacific coasts and interior of the United States during the year ending June 30, 1881.
1882	1	71-76	The same, 1881-1882.
1883	1	....	The same, 1882-1883.
1881	2	73-74	Statistics of field and office work of the United States Coast and Geodetic Survey for the year ending December 31, 1880.
1882	2	77-78	The same for the eighteen months ending June 30, 1882.
1883	2	....	The same for the year ending June 30, 1883.
1881	3	75-80	Information furnished from the Coast and Geodetic Survey Office from original sheets, transcripts, records, &c., in reply to special calls during the year ending June 30, 1881.
1882	3	79-84	Information furnished from the Coast and Geodetic Survey Office in reply to special calls during the year ending June 30, 1882.
1883	3	....	The same, 1883.
1881	4	81-83	Drawing Division.—Charts completed or in progress during the year ending June 30, 1881.
1882	4	85-86	The same, 1882.
1881	5	84-90	Engraving Division.—Plates completed, continued, or commenced during the year ending June 30, 1881.
1882	5	87-93	The same, 1882.
1881	6	91-123	General index of scientific papers, methods, and results contained in the appendices to the annual reports of the United States Coast and Geodetic Survey, from 1845 to 1880, inclusive. Compiled by C. H. Sinclair, Subassistant.
1882	6	95-106	Office reports for the fiscal year ending June 30, 1882.
1883	4	....	Report of the Assistant in charge of the office and topography for the fiscal year ending June 30, 1883.
1883	5	....	Report of the Hydrographic Inspector for the fiscal year ending June 30, 1883.
1883	6	....	Descriptive catalogue of publications relating to the Coast and Geodetic Survey and to standard measures. Compiled by Edward Goodfellow, Assistant.

III.

LIST OF TIDE TABLES FROM THE DATE OF EARLIEST PUBLICATION IN THE SURVEY TO THE YEAR 1881.

UNITED STATES COAST SURVEY.

Year of publication.	Description.	No. of pages and size.	Mode of publication.
1854	**Tide tables** for the United States; prepared from the Coast Survey observations by A. D. Bache, Superintendent.	4, quarto	Appendix No. 26, report for 1853.
1855	**Tide tables** for the coast of the United States	10, quarto	Appendix No. 51, report for 1854.
1856	**Tide tables** for the use of navigators; prepared from the Coast Survey observations by A. D. Bache, Superintendent.	12, quarto	Appendix No. 53, report for 1855.
1856	do	14, quarto	Appendix No. 17, report for 1856.
1858	do	21, quarto	Appendix No. 20, report for 1857.
1859	do	22, quarto	Appendix No. 43, report for 1858.
1860	do	32, quarto	Appendix No. 14, report for 1859.
1861	do	34, quarto	Appendix No. 16, report for 1860.
1862	do	34, quarto	Appendix No. 9, report for 1861.
1864	do	34, quarto	Appendix No. 8, report for 1862.
1864	do	34, quarto	Appendix No. 12, report for 1863.
1866	do	33, quarto	Appendix No. 8, report for 1864.

TIDE TABLES FROM THE DATE OF EARLIEST PUBLICATION, &c.—Continued.

Year of publication.	Description.	No. of pages and size.	Mode of publication.
1866..........	Tide tables for the Atlantic Coast of the United States for the year 1867.	101, 12mo....	Pamphlet [Government Printing Office].
1866..........	Tide tables for the Pacific Coast of the United States for the year 1867.	32, 12mo....	Do.
1867	Tide tables for the Atlantic Coast of the United States for the year 1868.	109, 12mo....	Do.
1867..........	Tide tables for the Pacific Coast of the United States for the year 1868.	58, 12mo....	Do.
1868..........	Tide tables for the Atlantic Coast of the United States for the year 1869.	110, 12mo....	Do.
1868..........	Tide tables for the Pacific Coast of the United States for the year 1869.	58, 12mo....	Do.
1869..........	Tide tables for the Atlantic Coast of the United States for the year 1870.	111, 12mo....	Do.
1869..........	Tide tables for the Pacific Coast of the United States for the year 1870.	59, 12mo....	Do.
1870..........	Tide tables for the Atlantic Coast of the United States for the year 1871.	112, 12mo....	Do.
1870..........	Tide tables for the Pacific Coast of the United States for the year 1871.	59, 12mo....	Do.
1871..........	Tide tables for the Atlantic Coast of the United States for the year 1872.	119, 12mo....	Do.
1871..........	Tide tables for the Pacific Coast of the United States for the year 1872.	59, 12mo....	Do.
1872..........	Tide tables for the Atlantic Coast of the United States for the year 1873.	121, 12mo....	Do.
1872..........	Tide tables for the Pacific Coast of the United States for the year 1873.	60, 12mo....	Do.
1873..........	Tide tables for the Atlantic Coast of the United States for the year 1874.	122, 12mo....	Do.
1873..........	Tide tables for the Pacific Coast of the United States for the year 1874.	60, 12mo....	Do.
1874..........	Tide tables for the Atlantic Coast of the United States for the year 1875.	122, 12mo....	Do.
1874..........	Tide tables for the Pacific Coast of the United States for the year 1875.	61, 12mo....	Do.
1875	Tide tables for the Atlantic Coast of the United States for the year 1876.	109, 12mo....	Do.
1875..........	Tide tables for the Pacific Coast of the United States for the year 1876.	61 12mo....	Do.
1876..........	Tide tables for the Atlantic Coast of the United States for the year 1877.	124, 12mo....	Do.
1876..........	Tide tables for the Pacific Coast of the United States for the year 1877.	61, 12mo....	Do.
1877..........	Tide tables for the Atlantic Coast of the United States for the year 1878.	124, 12mo....	Do.
1877..........	Tide tables for the Pacific Coast of the United States for the year 1878.	61, 12mo....	Do.
1878	Tide tables for the Atlantic Coast of the United States for the year 1879.	128, 12mo....	Do.
1878..........	Tide tables for the Pacific Coast of the United States for the year 1879.	65, 12mo....	Do.

UNITED STATES COAST AND GEODETIC SURVEY.

1879	Tide tables for the Atlantic Coast of the United States for the year 1880.	129, 12mo....	Pamphlet [Government Printing Office].
1879..........	Tide tables for the Pacific Coast of the United States for the year 1880.	65, 12mo....	Do.
1880..........	Tide tables for the Atlantic Coast of the United States for the year 1881.	129, 12mo....	Do.
1880	Tide tables for the Pacific Coast of the United States for the year 1881.	65, 12mo....	Do.

IV.

CATALOGUE OF COAST PILOTS FOR THE ATLANTIC AND PACIFIC COASTS OF THE UNITED STATES FROM THE DATE OF EARLIEST PUBLICATION BY THE COAST SURVEY TO THE YEAR 1881.

UNITED STATES COAST SURVEY.

Year of publication.	Title.	No. of pages and size.	No. of charts, views, &c.	Mode of publication.
1859	Directory for the Pacific Coast of the United States, reported to the Superintendent of the United States Coast Survey by George Davidson, Assistant. (First edition.)	162, quarto	....	Coast Survey report, 1858. Appendix 44.
1864	The same. (Second edition)	163, quarto	....	Coast Survey report, 1862. Appendix 39.
1869	Pacific Coast. Coast Pilot of California, Oregon, and Washington Territory. By George Davidson, Assistant, Coast Survey.	262, quarto	33	1 volume, Government Printing Office, 1869.
1869	Pacific Coast. Coast Pilot of Alaska. (First part.) From southern boundary to Cook's Inlet. By George Davidson, Assistant, Coast Survey.	251, quarto	8	1 volume, Government Printing Office, 1869.
1875	Coast Pilot for the Atlantic sea-board. Gulf of Maine and its coast from Eastport to Boston. 1874. By J. S. Bradford, Assistant.	960, quarto	12	1 volume, Government Printing Office, 1875.
1878	Atlantic Coast Pilot. Boston Bay to New York	628, quarto	55	1 volume, Government Printing Office, 1878.
1879	Atlantic Coast Pilot. Boston Bay to Monomoy	92, quarto	4	1 volume, Government Printing Office, 1879.
1879	Atlantic Coast Pilot. Nantucket and Vineyard Sounds.	107, quarto	7	1 volume, Government Printing Office, 1879.
1879	Atlantic Coast Pilot. Buzzard's and Narragansett Bays.	122, quarto	4	1 volume, Government Printing Office, 1879.
1879	Atlantic Coast Pilot. Block Island and Fisher's Island Sounds, Gardiner's and Peconic Bays.	66, quarto	4	1 volume, Government Printing Office, 1879.
1879	Atlantic Coast Pilot. Long Island Sound and East River.	86, quarto	6	1 volume, Government Printing Office, 1879.
1879	Atlantic Coast Pilot. Harbors in Long Island Sound	112, quarto	4	1 volume, Government Printing Office, 1879.
1879	Atlantic Coast Pilot. South coast of Long Island, New York Bay, and Hudson River.	90, quarto	22	1 volume, Government Printing Office, 1879.
	NOTE.—The seven volumes above named, published early in the year 1879, comprise a series intended to meet local wants, and are all contained in the one volume of the Atlantic Coast Pilot for 1878, compiled and verified by J. S. Bradford, Assistant.			

UNITED STATES COAST AND GEODETIC SURVEY.

Year of publication.	Title.	No. of pages and size.	No. of charts, views, &c.	Mode of publication.
1879	Atlantic Coast Pilot. Division A. Eastport to Boston. (Second edition.)	694, quarto	56	1 volume, Government Printing Office, 1879.
1879	Atlantic Local Coast Pilot. Subdivision 1. Passamaquoddy Bay to Schoodic.	115, quarto	10	1 volume, Government Printing Office, 1879.
1879	Atlantic Local Coast Pilot. Subdivision 2. Frenchman's Bay to Isle-au-haut.	190, quarto	7	1 volume, Government Printing Office, 1879.
1879	Atlantic Local Coast Pilot. Subdivision 3. Penobscot Bay and tributaries. (First edition.)	121, quarto	18	1 volume, Government Printing Office, 1879.
1879	Atlantic Local Coast Pilot. Subdivision 4. White Head Island to Cape Small Point.	126, quarto	6	1 volume, Government Printing Office, 1879.
1879	Atlantic Local Coast Pilot. Subdivision 5. Cape Small Point to Cape Ann.	141, quarto	10	1 volume, Government Printing Office, 1879.
1879	Atlantic Local Coast Pilot. Subdivision 6. Cape Ann to Cohasset.	107, quarto	5	1 volume, Government Printing Office, 1879.
	NOTE.—The six volumes of the Atlantic Local Coast Pilot named above and published about the middle of the year 1879 appear as separate parts of the large volume "Atlantic Coast Pilot, Division A, Eastport to Boston" (second edition), compiled by J. S. Bradford, Assistant.			
1879	Pacific Coast Pilot. Coast and islands of Alaska. Second series. Appendix 1. Meteorology and bibliography. By W. H. Dall, Assistant.	375, quarto	27	1 volume, Government Printing Office, 1879.

CATALOGUE OF COAST PILOTS FOR THE ATLANTIC AND PACIFIC COASTS, &c.—Continued.

Year of publication.	Title.	No. of pages and size.	No. of charts, views, &c.	Mode of publication.
1880	Atlantic Coast Pilot. Division B. Boston to New York. (Second edition.)	675, quarto	53	1 volume, Government Printing Office, 1880.
1880	Atlantic Local Coast Pilot. Subdivision 7. Boston to Monomoy.	86, quarto	5	1 volume, Government Printing Office, 1880.
1880	Atlantic Local Coast Pilot. Subdivision 8. Nantucket and Vineyard Sounds.	116, quarto	9	1 volume, Government Printing Office, 1880.
1880	Atlantic Local Coast Pilot. Subdivision 9. Buzzard's and Narragansett Bays.	131, quarto	5	1 volume, Government Printing Office, 1880.
1880	Atlantic Local Coast Pilot. Subdivision 10. Block Island and Fisher's Island Sounds; Gardiner's and Peconic Bays.	70, quarto	5	1 volume, Government Printing Office, 1880.
1880	Atlantic Local Coast Pilot. Subdivision 11. Long Island Sound and East River.	92, quarto	6	1 volume, Government Printing Office, 1880.
1880	Atlantic Local Coast Pilot. Subdivision 12. Harbors in Long Island Sound.	126, quarto	4	1 volume, Government Printing Office, 1880.
1880	Atlantic Local Coast Pilot. Subdivision 13. South Coast of Long Island, New York Bay, and Hudson River.	95, quarto	21	1 volume, Government Printing Office, 1880.
	NOTE.—The volumes of the Atlantic Local Coast Pilot numbered as Subdivisions 7 to 13 inclusive, and enumerated as above, appear as separate parts of the large volume Atlantic Coast Pilot, Division B, Boston to New York (second edition), and like that volume were compiled and prepared for publication by J. S. Bradford, Assistant.			

V.

CATALOGUES OF MAPS AND CHARTS PUBLISHED BY THE COAST AND GEODETIC SURVEY BETWEEN THE YEARS 1835 AND 1881.

UNITED STATES COAST SURVEY.

Date of publication.		Title of catalogue.	No. of pages and size.	No. of maps and charts.	Mode of publication.
Catalogue.	Charts.				
1843	1835–1842	List of the individual maps executed and delivered. NOTE.—The list above named is published also in Report No. 170, designated as Twenty-seventh Congress, third session, Report No. 170, House of Representatives.	1, octavo	8	Twenty-seventh Congress, third session, Report No. 43, House of Representatives. (Report of Select Committee on Coast Survey.)
1849	1842–1849	List of Coast Survey maps engraved	1, octavo	33	Thirty-first Congress, first session, Executive Document 5, Senate. (Report of Superintendent Coast Survey for 1849. Appendix No. 2, *bis*.)
1850	1842–1850	do	1, octavo	43	Thirty-first Congress, second session, Executive Document 12, House of Representatives. (Report of Superintendent Coast Survey for 1850. Appendix No. 38.)
1852	1842–1851	List of Coast Survey maps, sketches, and preliminary charts, engraved.	2, octavo	78	Thirty-second Congress, first session, Executive Document 3, Senate. (Report of Superintendent Coast Survey for 1851. Appendix No. 11.)
1853	1842–1852	List of Coast Survey maps, sketches, and preliminary charts.	2, quarto	89	Thirty-second Congress, second session, Executive No. 64, House of Representatives. (Report of Superintendent Coast Survey for 1852. Appendix 6.)

CATALOGUE OF MAPS AND CHARTS, &c.—Continued.

Dates of publication.		Title of catalogue.	No. of pages and size.	No. of maps and charts.	Mode of publication.
Catalogue.	Charts.				
1854	1842-1853	List of Coast Survey maps, sketches, and preliminary charts.	2, quarto	129	Thirty-third Congress, first session, Executive 14, Senate. (Report of Superintendent Coast Survey for 1853. Appendix 5.)
1855	1842-1854	do	3, quarto	147	Thirty-third Congress, second session, Executive 20, House of Representatives. (Report of Superintendent Coast Survey for 1854. Appendix 31.)
1856	1842-1855	do	4, quarto	192	Thirty-fourth Congress, first session, Executive 6, House of Representatives. (Report of Superintendent Coast Survey for 1855. Appendix 36.)
1856	1842-1856	List of Coast Survey maps, preliminary charts, and sketches, engraved, geographically arranged.	5, quarto	221	Thirty-fourth Congress, third session, Executive 12, Senate. (Report of Superintendent Coast Survey for 1856. Appendix 19.)
1858	1842-1857	do	6, quarto	240	Thirty-fifth Congress, first session, Executive 33, Senate. (Report of Superintendent Coast Survey for 1857. Appendix 22.)
1859	1842-1858	List of Coast Survey maps, preiminary charts, and sketches, engraved, geographically arranged.	6, quarto	260	Thirty-fifth Congress, second session, Executive 14, Senate. (Report of Superintendent Coast Survey for 1858. Appendix 19.)
1860	1842-1859	do	6, quarto	268	Thirty-sixth Congress, first session, Executive 41, House of Representatives. (Report of Superintendent Coast Survey for 1859. Appendix 17.)
1861	1842-1860	do	6, quarto	278	Thirty-sixth Congress, second session, Executive —, Senate. (Report of Superintendent Coast Survey for 1860. Appendix 19.)
1862	1842-1861	do	6, quarto	290	Thirty-seventh Congress, second session, Executive —, Senate. (Report of Superintendent Coast Survey for 1861. Appendix 12.)
1863	1846-1863	Catalogue of hydrographic maps, charts, and sketches published by the United States Coast Survey. A. D. Bache, Superintendent. 1863.	17, quarto	242	Washington. Government Printing Office. 1863.
1866	1846-1864	Catalogue of hydrographic maps, charts, and sketches published by the United States Coast Survey. A. D. Bache, Superintendent. 1866.	17, quarto	242	Washington. Government Printing Office.
1867	1846-1867	Same. Benjamin Peirce, Superintendent. 1867.	18, quarto	276	Do.
1872	1846-1872	Same. Benjamin Peirce, Superintendent. 1872.	20, quarto	278	Do.
1875	1851-1875	United States Coast Survey. Carlile P. Patterson, Superintendent. Catalogue of charts. 1875.	28, quarto	299	Do.
1877	1851-1877	Catalogue of charts of the United States Coast Survey, 1877. Carlile P. Patterson, Superintendent.	29, quarto	325	Do.
1880	1846-1880	United States Coast and Geodetic Survey. Catalogue of charts. 1880. Carlile P. Patterson, Superintendent.	45, quarto	409	Do.

NOTE.—At the date of publication of this list, the latest edition of the Catalogue of Charts published is that for 1883, J. E. Hilgard, Superintendent.

VI.

NOTICES TO MARINERS FROM THE DATE OF EARLIEST PUBLICATION BY THE COAST SURVEY TO THE YEAR 1881.

UNITED STATES COAST SURVEY.

No.	Date of notice.	Title.
	1869, July 12	Notice to Mariners. Pacific Coast. Shoal off Cape Reyes, Cal.
	1872, Jan. 22	Notice to Mariners. Atlantic Coast. East coast of Florida. Saint Lucie Shoal.
	1874, June 20	Notice to Mariners. Northwest coast of America. Aleutian Islands.
	1874, Oct. 10	Notice to Mariners. Atlantic Coast. Long Island Sound.
1	1875, Jan. 14	Notice to Mariners, No. 1. Atlantic Coast. Sailing directions for Saint Augustine Harbor.
2	1875, Jan. 20	Notice to Mariners, No. 2. Pacific Coast. Sailing directions for Mack's Shelter, Oreg.
3	1875, Feb. 10	Notice to Mariners, No. 3. Pacific Coast. Sunken rock off the boundary of California and Oregon.
4	1875, May 4	Notice to Mariners, No. 4. Pacific Coast. Additional peaks, Noonday Rock. Entrance to San Francisco Bay, Cal.
5	1875, May 7	Notice to Mariners, No. 5. Pacific Coast. Sunken rock off Cape Mendocino, Cal.
6	1875, May 20	Notice to Mariners, No. 6. Pacific Coast. Sunken Rocks. San Luis Obispo Bay, Cal.
7	1875, July 24	Notice to Mariners, No. 7. Pacific Coast. Shoal near South Farallon.
8	1875, Sept. 4	Notice to Mariners, No. 8. Pacific Coast. Dangerous Shoal in the northern approach to San Miguel Passage.
9	1875, Sept. 20	Notice to Mariners, No. 9. Atlantic Coast. Approaches to Chesapeake Bay. Wreck 12 miles to the southward and eastward of Cape Henry.
10	1875, Nov. 4	Notice to Mariners, No. 10. Atlantic Coast. Ledge in Delaware River.
11	1876, Feb. 8	Notice to Mariners, No. 11. Gulf of Mexico. Positions of wrecks at the entrance of Pensacola Bay, Fla.
12	1877, May 16	Notice to Mariners, No. 12. Atlantic Coast. Chesapeake Bay. Wreck off New Point Comfort, Va.
13	1877, Dec. 15	Notice to Mariners, No. 13. Atlantic Coast. Wreck off Currituck Beach, N. C.
14	1877, Dec. 21	Notice to Mariners, No. 14. Gulf of Mexico. Observations upon northers and southeast gales.
15	1878, Mar. 7	Notice to Mariners, No. 15. Gulf of Maine. Tidal currents at entrance.
15	1878, June 15	Notice to Mariners, No. 15. Gulf of Maine. Tidal currents at entrance. [Second edition.]
16	1878, May 9	Notice to Mariners, No. 16. Atlantic Coast. Florida Reefs. Disappearance of a beacon.
17	1878, July 16	Notice to Mariners, No. 17. Atlantic Coast. Nantucket Sound. Wreck in Hyannis Harbor.

NOTE.—This list begins with the earliest separate publication of these notices on file in the Coast and Geodetic Survey Office. The annual reports previous to 1869 contain many such notices in the form of communications from the Superintendent to the Secretary of the Treasury, with requests that authority be given to publish for the benefit of mariners. The separate publications of these notices since 1869 are for special distribution, and are supplementary to the publication formerly made and still continued in the leading commercial and nautical journals.

For general lists of discoveries and developments see the Reports from 1850 to 1864, inclusive.

UNITED STATES COAST AND GEODETIC SURVEY.

No.	Date of notice.	Title.
18	1879, June 27	Notice to Mariners, No. 18. Pacific Coast. Depth of water over the bar at entrance of Wilmington Harbor, Cal.
19	1879, June 27	Notice to Mariners, No. 19. Coast of Alaska. Location of Keen Rock in the middle passage to Sitka Harbor, Alaska.
20	1879, June 27	Notice to Mariners, No. 20. Atlantic Coast. Closing of New Inlet, mouth of Cape Fear River, N. C.
21	1879, July 9	Notice to Mariners, No. 21. Atlantic Coast. Increased depth of water at entrance of Cape Fear River, N. C.
22	1879, July 14	Notice to Mariners, No. 22. Atlantic Coast. Sunken wreck in the track of vessels running along the New Jersey coast.
23	1879, July 25	Notice to Mariners, No. 23. Atlantic Coast. Development of Johnson's Rock, Casco Bay, Me.
24	1879, Oct. 14	Notice to Mariners, No. 24. Atlantic Coast. Dangerous rock near Isle of Wight Shoal. Coast of Maryland.
25	1879, Nov. 15	Notice to Mariners, No. 25. Atlantic Coast. Development of Schuyler's Ledge, off Sakonnet Point, R. I.
26	1880, June 7	Notice to Mariners, No. 26. Pacific Coast. Development of dangerous rocks near Fort Ross, Cal.
27	1880, Dec. 16	Notice to Mariners, No. 27. Atlantic Coast. Sunken wreck in entrance to Rappahannock River, Va.
28	1881, Apr. 26	Notice to Mariners, No. 28. Atlantic Coast. Improvements of rivers and harbors on the coasts of Maine and Massachusetts, under the direction of Gen. George Thom, Engineer Corps, United States Army.
29	1881, Apr. 27	Notice to Mariners, No. 29. Atlantic Coast. Connecticut. Breakwater in process of construction to the westward of Bartlett's Reef. Fisher's Island Sound.

NOTE.—The greater number of the above-named notices are printed somewhat as handbills, in large type for easy reading, and occupy about one page quarto.

VII.

SPECIAL PUBLICATIONS.

UNITED STATES COAST SURVEY.

Year of publication.	Title.	No. of pages and size.	Mode of publication.
1858	Laws relating to the survey of the coast of the United States, with the plan of reorganization of 1843, and regulations by the Treasury Department.	25, octavo	Public Printer, 1858.
1862	Standard places of fundamental stars. (First edition.)	15, quarto	Washington, Government Printing Office, 1862.
1866	The same. (Second edition.)	15, quarto	Washington, Government Printing Office, 1866.
1869	Statutes relating to the Survey of the Coast of the United States, with the plan of reorganization of 1843, and regulations by the Treasury Department.	27, duodecimo	Washington, Government Printing Office, 1869.
1874	United States Coast Survey. Carlile P. Patterson, Superintendent. The Star factors A, B, C, for reducing Transit observations. 1874.	69, quarto	Washington, Government Printing Office, 1874.
1874	United States Coast Survey. Field catalogue of 983 transit stars. Mean places for 1870.0.	32, octavo	Do.
1874	United States Coast Survey Report, 1874. Appendix. Tidal researches. By William Ferrel, A. M., member of the National Academy of Sciences, Assistant United States Coast Survey. (With four illustrations.)	268, quarto	Do.
1874	United States Coast Survey. On the air contained in sea water, by Oscar Jacobsen. Republished for the United States Coast Survey, from Annals Ch. and Ph., Vol. 167, 1873.	16, quarto	Do.
1874	United States Coast Survey. Report on the Nicaragua route for an interoceanic ship-canal, with a review of other proposed routes; made by Maximilian Von Sonnenstern to the minister of public works of Nicaragua. (One illustration.) (Translated for the United States Coast Survey.)	22, quarto	Do.
1875	General Instructions in regard to the hydrographic work of the Coast Survey. Four illustrations. (Printed for the use only of the hydrographic parties.)	25, octavo	Washington, Government Printing Office, 1875.
1875	On tides and tidal action in harbors, by Prof. J. E. Hilgard, of the United States Coast Survey. (Reprinted from the Smithsonian Report for 1874.)	22, octavo	Do.
1877	United States Coast Survey. Carlile P. Patterson, Superintendent. Methods, discussions, and results. Field-work of the triangulation. By Richard D. Cutts, assistant. (Reprinted, with additions from the Coast Survey report for 1868.)	45, quarto	Washington, Government Printing Office, 1877.
1878	General Instructions in regard to inshore hydrographic work of the Coast Survey, 1878.	50, octavo	Washington, Government Printing Office, 1878.
1879	Cost of certain surveys	4, octavo	Forty-fifth Congress, third session, House of Representatives, Executive Document 29.
1879	United States Coast and Geodetic Survey. Carlile P. Patterson, Superintendent. Methods and Results. Secular change of magnetic declination in the United States and at some foreign stations. (Third edition. With two plates.)	50, quarto	Washington, Government Printing Office, 1879.
1880	United States Coast and Geodetic Survey. Carlile P. Patterson, Superintendent. Deep-sea sounding and dredging. A description and discussion of the methods and appliances used on board the Coast and Geodetic Survey steamer Blake. By Charles D. Sigsbee, lieutenant-commander, U. S. Navy, Assistant in the Coast and Geodetic Survey. (With 54 illustrations.)	221, quarto	Washington, Government Printing Office, 1880.
1881	United States Coast and Geodetic Survey, Carlile P. Patterson, Superintendent. Methods and Results. General properties of the equations of steady motion.	26, quarto	Washington, Government Printing Office, 1881.
1881	Laws and Regulations relating to the Coast and Geodetic Survey of the United States.	42, octavo	Treasury Department, Document 110, Coast and Geodetic Survey.
1881	Laws of general application for the use of the United States Coast and Geodetic Survey.	52, octavo	Treasury Department, Document 167, Coast and Geodetic Survey.

APPENDIX No. 7.

A TABLE OF DEPTHS FOR THE HARBORS ON THE COASTS OF THE UNITED STATES.

The following table, showing the best water that can be taken through the entrances and up to the usual anchorages in the harbors of the United States and those of the immediately adjacent coasts, was first prepared in outline (under instructions from the Superintendent) by Commander Edward P. Lull, U. S. Navy, Hydrographic Inspector United States Coast and Geodetic Survey, and afterwards expanded and perfected in detail by Assistant J. S. Bradford, aided by Mr. Jno. W. Parsons.

TIDES.

I. *From Eastport, Me., to Saint Augustine, Fla.*, the tides are of the semi-diurnal type, the two tides of the same day being practically equal in range. There is, however, a marked difference between the range of "spring" tides (that is, those which follow the full and change of the moon) and that of the "neap" tides (those following her first and third quarters), the range of the former being above, and that of the latter below the average.

II. *Passing southward from Saint Augustine*, the range of the tides is considerably diminished, and the modification due to the moon's declination becomes more and more apparent: That is, near the periods of the moon's greatest declination north or south there is an inequality in the range of the two tides of the same day, which disappears as the moon approaches and crosses the equator.

III. *Passing up the western coast of the peninsula of Florida*, the semi-diurnal tides gradually disappear. To the northward and westward of Cedar Keys, and thence to the mouth of the Rio Grande, there is but one astronomical tide during each lunar day, and that of small range. This tide is of greatest range at and near the periods of the moon's greatest declination north or south, and disappears at the time of the moon's crossing the equator. "Wind-tides" are very marked—southerly winds (particularly if prevailing for several days) raising the level of the water, and northerly winds having the opposite effect.

IV. *On the Pacific coast* (*including the southern coast of Alaska*), the tides are of the semi-diurnal type, the two tides of the same day having different ranges. The inequality increases as the moon moves north or south from the equator; is greatest at the moon's greatest declination; decreases as she approaches the equator; and disappears at the period of no declination. There is also a sensible modification of the tides following the moon's phases. Thus, when the full or change occurs at or near the time of greatest declination, the range of tide will be somewhat augmented; and, on the other hand, if neap tides occur at the same period the range will be diminished.

TABLE OF DEPTHS.

ATLANTIC COAST.

NOVA SCOTIA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	Feet.	Feet.	Feet.	
Halifax Harbor	To anchorage off George Island	36	41½	35½	41½	British Admiralty, 1853.
Sambro Harbor	To anchorage	24	30	23¼	30¾	British Admiralty, 1867.
Pennant Harbor	......do	42	48	41¼	48¾	Do.
Tennant's Harbor	......do	42	48	41¼	48¾	British Admiralty, 1861.
Shag Bay	......do	42	48	41¼	48¾	Do.
Blind Bay	......do	30	36	29¼	36¾	Do.
Dover Port	To anchorage inside Taylor's Island	42	48	41¼	48¾	Do.
Margaret's Bay	To anchorage inside Jollimore's Island	30	36	29¼	36¾	Do.
	To anchorage in French Cove	42	48	41¼	48¾	Do.
	To anchorage in Head Harbor	36	42	35¼	42¾	Do.
	To anchorage in Hubbert's Cove	30	36	29¼	36¾	Do.
	To anchorage in Northwest Harbor inside Horse Island	36	42	35¼	42¾	Do.
Mahone Bay	To anchorage under Tancook Islands	42	48	41¼	48¾	Do.
	To anchorage off town of Chester	42	47¾	41¼	48¾	Do.
	To anchorage in Mahone Harbor	42	48	41¼	48¾	Do.
	To anchorage in Aspotagoen River	18	24	17¼	24¾	Do.
	To anchorage in East River Bay	45	51	44¼	51¾	Do.
	To anchorage in Scotch Cove	48	53¾	47¼	54¼	Do.
	To anchorage in West Chester Bay	42	47¾	41¼	48¼	Do.
	To anchorage in Chester Basin	24	29¾	23¼	30¼	Do.
	To anchorage under Oak Island	21	26¾	20¼	27¼	Do.
	To anchorage in Deep Cove	30	36	29¼	36¾	Do.
	To anchorage in Prince's Inlet	42	48	41¼	48¾	Do.
Malaguash Bay	To anchorage off town of Lunenburg	24	30	23¼	30¾	Do.
	At anchorage under Ovens Point	36	42	35¼	42¾	Do.
Rose Bay	At anchorage	27	33	26¼	33¾	Do.
Le Have River	To anchorage under Lee's Point	15	21	14¼	21¾	Do.
Green Bay	To anchorage	33	39	32¼	39¾	British Admiralty, 1867.
Port Metway	At anchorage inside Neil's Point	18	23	17½	25¾	Do.
	At anchorage in Northwest Bay	15	20	14½	22¾	Do.
Liverpool Bay	At anchorage off Brooklyn (Herring Cove)	18	23	17½	25¾	Do.
	At anchorage off Liverpool	12	17	11½	19¾	Do.
Port Mouton	To anchorage under western shore of Mouton Island	42	47¾	41½	49	Do.
	To anchorage west of the Spectacles	42	47¾	41½	49	Do.
	To anchorage through Western Channel	21	26¾	20½	28	British Admiralty, 1861.
Port Ebert	To anchorage off Shingle Point	15	21	14½	21¾	British Admiralty, 1867
Rugged Island Harbor	To anchorage off Clam Island	21	27	20¼	27¾	Do.
Green Harbor	To anchorage off Jenkin Island	21	27	20¼	27¾	Do.
Jordan River	To anchorage	22½	28½	22¼	29¼	Do.
Shelburne Harbor	To anchorage within half a mile of the town	33	38½	32½	39	Do.
Negro Harbor	At anchorage between East Point and Negro Island	33	38½	32¾	39	Do.
	At anchorage between Negro Island and Purgatory Point	27	32½	26¾	33¼	Do.
	At upper anchorage off Davis' Island	21	26½	20¾	27¼	Do.
Barrington Bay	To anchorage off Beach Point	21	27	20¾	27¾	Do.
Clarke Harbor (Cape Sable Island)	To anchorage	21	30	20½	30½	British Admiralty, 1865.
	To anchorage off northeast point of Sable Island	18	27	17½	27½	Do.
Saint Mary's Bay	To anchorage off Westport, inside Bryer Island	36	53	35	54	Do.
	To anchorage off Weymouth	42	59¾	41	60¾	Do.

Table of depths, Atlantic Coast—Continued.

NOVA SCOTIA, NEW BRUNSWICK, AND MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
BAY OF FUNDY (Harbors)	To anchorage in Shag Harbor, inside Mutton Island	33	41½	32¾	42⅓	British Admiralty, 1867
	To anchorage in Pubnico Harbor	30½	40	30	40⅓	Do.
	Jones' anchorage under eastern shore of Jones' Island	36	46⅓	35⅓	47	Do.
	At anchorage under Big Fish Island	19½	29½	18¾	30⅓	Do.
	To anchorage off Yarmouth	15	28	14¼	28¾	Do.
	Entrance to Annapolis Basin, through Digby Gut	90	113	89	114	Do.
	At anchorage off Digby	36	59	35	60	Do.
	To anchorage off Annapolis Royal	15	38	14	39	Do.
	To anchorage off Burnt-Coat Head, Basin of Mines	36	79½	34½	81	Do.
BAY OF FUNDY (Chignecto **Channel**)	In entrance and up to Cape Enragé	120	155¾	118½	159	Do.
	At anchorage off mouth of Tantremar River (Sackville entrance)	18	56	16¼	57¾	Do.
	At anchorage off Folly Point	19½	57½	17¾	59⅓	Do.
	At anchorage in Saint John Harbor on west side of Navy Island	51	74	50	75	British Admiralty, 1864.
	To anchorage in Musquash Harbor	12	34	11	35	British Admiralty, 1862.
BAY OF FUNDY (Harbors)	To anchorage in Lepreau Bay	24	45½	23½	43	Do.
	To anchorage in Lepreau Harbor	15	36½	14½	34	Do.
	To anchorage in Beaver Harbor	33	54½	32½	59	Do.
	To anchorages in Etang Harbor:					
	1. Off Etang village	47	68½	46½	69	British Admiralty, 1847.
	2. In Black Bay	33	54½	32½	59	Do.
	3. In Deadman's Bay	30	51½	29½	52	Do.
	To anchorage in Bliss Harbor	39	60½	38½	61	Do.
PASSAMAQUODDY BAY (Harbors)	To anchorage in Back Bay	27	48½	26½	49	Do.
	To anchorages in Saint Andrew's Harbor:					
	1. Off Joe Point	60	81	59	82	British Admiralty, 1868.
	2. Off eastern entrance	33	54	32	55	Do.
	3. In Inner Harbor, off Market wharf	12	33	11	34	Do.
	To anchorages in Chamcook Harbor:					
	1. In Outer or Northeast Harbor	48	69	47	70	Do.
	2. In Inner Harbor, off northwest end of Minister Island	33	54	32	55	Do.
Grand Manan Island	At anchorage in Seal Cove	36	54	34¾	55⅓	British Admiralty, 1862.
Eastport Harbor and approaches **(Maine)**	Passage by East Quoddy Head Light-house to Eastport	90	108	88¾	109⅓	Coast Survey, 1861.
	Passage by West Quoddy Head Light-house to Lower Middle Ground	21	39	19¾	40⅓	Do.
	Passage from West Quoddy Head to Lubec	8	26	6¾	27⅓	Do.
	Passage through Lubec Narrows (over the bar)	6½	24½	5⅓	26¾	Do.
	From Lubec to Shackford's Head buoy	37	55	35¾	56⅓	Do.
	From Lubec to Eastport, by Pope's Folly	31	49	29¾	50⅓	Do.
	From Eastport to Kendall's Head	81	99	79¾	100⅓	Do.
	To anchorage in Quoddy Roads, between Lower Middle Ground and Western Beacon	9	27	7¾	28⅓	Coast Survey, 1866.
	To anchorage in Quoddy Roads, below the Middle Ground	19	37	17¾	38⅓	Do.
	To anchorage in Johnson's Bay	10	28	8¾	29⅓	Do.
	To anchorage in Broad Cove (Moose Island)	9	27	7¾	28⅓	Coast Survey, 1861.
	To anchorage in Johnson's Cove (Moose Island)	13	31	11¾	32⅓	Do.
	To anchorage in Friar's Bay	27	45	25¾	46⅓	Do.
	To anchorage in Harbor de Lute	21	39	19¾	40⅓	Do.
East shore of Campobello Island	To anchorage in Herring Bay	16	34	14¾	35⅓	Do.
	To anchorage in Schooner Cove	12	30	10¾	31⅓	Do.
	To anchorage in Mill Cove	9	27	7¾	28⅓	Do.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
East shore of Campobello Island Continued.	To anchorages in Head Harbor:					
	1. At north end	6	24	4¾	25⅓	Coast Survey, 1861.
	2. At south end	9	27	7¾	28⅓	Do.
	3. Three quarters of a mile up	6	24	4¾	25⅓	Do.
	To anchorage in Great Duck Pond	8	26	6¾	27⅓	Coast Survey, 1866.
Deer Island	In entrance to Little Harbor	6	24	4¾	25⅓	Coast Survey, 1861.
	At the anchorage	9	27	7¾	28⅓	Do.
Northwest Harbor	do	6	24	4¾	25⅓	Do.
Saint Croix River	To "The Divide"	30	52	29	53	Atlantic Coast Pilot, 1874.
	To "The Ledge"	12	34	10	35	Do.
	To Calais	8	30⅓	5½	31	Do.
Bayley's Mistake	At the anchorage	24	40	23	41	Do.
Moose River	From entrance to anchorage	30	46	29	47	Do.
Little River	To anchorage off Ackley's Point	24	39	23	40	Do.
Little Machias Bay	From entrance to anchorage	24	39	23	40	Do.
Machias Bay	Through Main Channel to Machiasport	15	30	14	31	Do.
	From Machiasport to the draw-bridge	12	27	11	28	Do.
	From the draw-bridge to Machias	10	24	9	25	Do.
	Western channel—Avery's Rock to Machiasport	15	30	14	31	Do.
	Through Cross Island Narrows	24	39	23	40	Do.
Little Kennebec River	From entrance, through Ram Island Passage to anchorage	18	32	17	33	Do.
Englishman's Bay	Up Chandler's River to Jonesboro'	4	12	3	13	Do.
	Entrance, from the westward (outside all dangers) to Squier's Point	24	36	23	37	Do.
Moos-a-bec Reach	From eastward over Moos-a-bec Bar	7	18¾	6	19½	Coast Survey, 1870-'71
	Seguin Passage	25	36¾	24	37½	Do.
	Channel Reach	13	24¾	12	25½	Do.
	Western entrance, through Tabbott's Narrows	27	38¾	26	39½	Do.
	At anchorage in Moos a-bec Reach	19	30¾	18	31½	Do.
Head Harbor	To anchorage in "The Cow Yard"	12	23¾	11	24½	Atlantic Coast Pilot 1874.
Cape Split Harbor	To anchorage off Wright's Point	53	64¾	52	65½	Coast Survey, 1870-'71.
Beal's Harbor	To anchorage in the Harbor	15½	27	14½	28	Do.
Harrington River	To anchorage between Fisher's Island and Ripley's Neck	12	23	11	24	Atlantic Coast Pilot 1874.
	To anchorage off Nash's Point	6	17	5	18	Do.
Narraguagus Bay	To anchorage off Steamboat Wharf	12	23	11	24	Do.
	To anchorage off Patterson's Point	9	20	8	21	Do.
	Through Dyer's Island Narrows to anchorage	12	23	11	24	Do.
Pigeon Hill Bay	Through Main Channel to anchorage, above Chitman's Point	21	32	20	33	Do.
	From the Westward (outside Petit Manan Island) to anchorage	21	32	20	33	Do.
	From the westward (inside Petit Manan Island):					
	1. Over outer bar	9	20	8	21	Do.
	2. Over inner bar	7	18	6	19	Do.
Douglass Island Harbor	To anchorage	24	35	23	36	Do.
Dyer's Bay	do	24	35	23	36	Do.
Gouldsboro' Bay	Entering from eastward (outside Petit Manan Island) to anchorage	24	35	23	36	Do.
	Entering from westward, to northward or southward of Moulton's Ledge	18	29	17	30	Do.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	* Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Prospect Harbor	Entrance between Big Black Ledge and Cranberry Point	69	79¾	68	80½	Coast Survey, 1871.
	Entrance between Old Woman's Ledge and mouth of Birch Creek	49	59¾	48	60½	Do.
	To anchorage in Sand Cove, above "The Sands"	7½	18¼	6½	19	Do.
	At the anchorage in Inner Harbor, abreast of the Village	21	31¾	20	32½	Do.
Birch Harbor	Entrance to harbor	19	29¾	18	30½	Do.
	To anchorage, half-way up	6	16¾	5	17½	Do.
	At the anchorage	12	22¾	11	23½	Do.
Bunker's Harbor	Northeast entrance	22	32¾	21	33½	Do.
	Southwest entrance	7	17¾	6	18½	Do.
	At the anchorage	16	26¾	15	27½	Do.
Schoodic Harbor	At anchorage, west of Rowland's Island	45	55¾	44	56½	Do.
	At anchorage on western side of Spruce Point	27	37¾	26	38½	Do.
	To anchorage near head of harbor	19½	29¾	18	30½	Do.
FRENCHMAN'S BAY and tributaries.	To anchorage in Pond Island Cove	16	26½	15¼	27¼	Coast Survey, 1873.
	To anchorage in Mosquito Harbor, between Fraser's Point and Holmes' Island	12	22½	11¼	23¼	Do.
	At anchorage in Henry Cove	21	31½	20¼	32¼	Do.
	At anchorage in Winter Harbor, west of Village	11	21½	10¼	22¼	Do.
	At anchorage in Sand Cove (Winter Harbor)	30	40½	29¼	41½	Do.
	At anchorage in Deep Cove	17	27½	16¼	28¼	Do.
	Over Jordan's Bar	5	15½	4¼	16¼	Do.
	Passage through Halibut Hole	61½	76½	60¾	77¼	Atlantic Coast Pilot 1874.
Bar Harbor	At anchorage off the Village	24	34½	23¼	35	Coast Survey, 1873.
	At anchorage to westward of the bar	7	17½	6½	18	Do.
	Passage between Bar Island and Sheep Porcupine Island	12½	23	11¾	23½	Do.
	Up the bay to Sands' Point	108	118½	107¼	119	Do.
	At anchorage in Hull's Cove	16	26½	15¼	27	Do.
FRENCHMAN'S BAY and tributaries.	Entrance to Stave Island Harbor:					
	1. Over Jordan's Bar	5	15½	4¼	16¼	Do.
	2. Between Jordan's and Stave Islands	39	49½	38¼	50¼	Coast Survey, 1882.
	At the anchorage between Jordan's Island and the mainland	36	46½	35¼	47¼	Do.
	Entrance to Bass Cove or East Sullivan Harbor:					
	1. Southern Channel, between Stave and Calf Islands	11	21½	10¼	22¼	Do.
	2. Northern Channel, between Calf and Preble Islands	69	79½	68¼	80¼	Do.
	At anchorage off West Gouldsboro'	42	52½	41¼	53¼	Do.
	At anchorage under Waukeag Neck	36	46½	35¼	47¼	Do.
	At anchorage in Basin Cove	15	25½	14¼	26¼	Do.
	In entrance to Sullivan Harbor (or Flanders Bay)	60	70½	59¼	71¼	Do.
	Up Flanders Bay to anchorage off Sullivan	28½	39	27¾	39¾	Do.
	Up Flanders Bay to West Sullivan	12	22½	11¼	23¼	Do.
	From West Sullivan to Crabtree's Island	16	26½	15¼	27¼	Do.
	At anchorage in Egypt Bay	16	26½	15¼	27¼	Do.
	Over "The Falls"	12	22½	11¼	23¼	Do.
	From Crabtree's Island to Franklin	5	15½	4¼	16¼	Do.
	At the anchorage in Franklin Bay	30	40½	29¼	41¼	Do.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
FRENCHMAN'S BAY and tributaries—Continued.	Entrance to Skillings' River	66	76½	65¼	77¼	Coast Survey, 1882.
	From the entrance to Lower Narrows	31½	42	30¾	42¾	Do.
	Through Lower Narrows	19½	30	18¾	30¾	Do.
	From the Lower Narrows to Young's Point	34½	45	33¾	45¾	Do.
	At anchorage in Young's Bay (off Hancock)	9	19½	8¼	20¼	Do.
	From Young's Point to Seal Point	25½	36	24¾	36¾	Do.
	At anchorage in Partridge's Cove	11	21½	10¼	22¼	Do.
	Through Upper Narrows	16	26½	15¼	27¼	Do.
	At anchorage in Kilkenny Cove	19	29½	18¼	30¼	Do.
	At anchorage in Raccoon Cove	8	18½	7¼	19¼	Do.
Eastern Bay	Entrance between Sands' Point and Meadow Point	90	108½	89½	108¾	Coast Survey, 1874.
	Through the bay from Sands' Point to Thomas' Island	36	46½	35¼	46¾	Do.
	From abreast of Thomas' Island to the Bridge	−1	9½	−1¾	9¾	Do.
	In the entrance to Jordan's River	11	21½	10¼	21¾	Do.
	To anchorage off Lemoine, (Jordan's River)	8½	18¾	7¾	19½	Do.
	At the anchorage in Thomas' Bay	10	20½	9¼	20¾	Do.
Otter Creek	At the anchorage*	8	18½	7¾	19½	Do.
Southwest Harbor and adjacent anchorages.	In main entrance to Southwest Harbor:					
	1. North of Sutton's Island	60	70	59¼	70¾	Coast Survey, 1871.
	2. South of Sutton's Island	22½	32½	22	33¼	Do.
	At anchorage off Lobster-factory wharf.	22½	32½	22	33¼	Do.
	Entrance from the westward over Cranberry Island Bar	14	24	13½	24¾	Do.
Cove of Stony Beach	At anchorage*	36	46	35½	46¾	Do.
Seal Harbor	do	15	25	14¼	25½	Do.
Long Pond Harbor	do	9	19	8¼	19½	Do.
Northeast Harbor	In Main Channel entrance (west of Bear Island)	33	43	32½	43¾	Do.
	Passage north of Bear Island	6	16	5½	16¾	Do.
	At anchorage	21	31	20½	31¾	Do.
Somes' Sound	In main channel east of Greening's Island to "The Narrows"	40½	50½	40	51¼	Do.
	Through the Narrows	49½	59½	49	60¼	Do.
	Passage between Greening's Island and Clarke's Point	18	28	17½	28¾	Do.
	Up the Sound from the Narrows to Bar Island	45	55	44½	55¾	Do.
	At the Anchorage off Somesville	16½	26½	16	27¼	Do.
	At the anchorage at head of Sound	28½	38½	28	39¼	Do.
Cranberry Island Harbors	In entrance to Great Cranberry Island Harbor	21	31	20½	31¾	Coast Survey, 1874.
	In entrance to "The Pool"	3	13	2½	13¾	Do.
	At the anchorage in the Harbor	13	23	12½	23¾	Do.
	At the anchorage in "The Pool"	9	19	18½	19¾	Do.
	Through between Great and Little Cranberry	5	15	4½	15¾	Do.
	At anchorage in Little Cranberry Island Harbor:					
	1. East side of harbor	19½	29½	19	30¼	Do.
	2. West side of harbor	24	34	23½	34¾	Do.
Bass Harbor	From the eastward over Bass Harbor Bar	14	24	13½	24¾	Do.
	At the anchorage in Outer Harbor	27	37	26½	37¾	Do.
	At the anchorage in Inner Harbor	19	29	18½	29¾	Do.
	Entrance from Blue Hill Bay	51	61	50½	61¾	Do.
	Entrance by passage between Placentia and the Gott Islands	30	40	29½	40¾	Do.
	Channel to westward of Weaver's Ledge	30	40	29½	40¾	Do.

* Little shelter, and rarely used.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Least water in channel. Mean. High water.	Least water in channel. Spring tides. Low water.	Least water in channel. Spring tides. High water.	Authorities.
Blue Hill Bay and tributaries	Channels:	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
	1. Entrance over Bass Harbor Bar	14	24	13⅓	24¾	Coast Survey, 1874.
	2. Entrance between the Gott Islands and Black Island	78	88	77⅓	88¾	Coast Survey, 1876.
	3. Main Channel from eastward between the Green Islands and Long Island	84	94	83⅓	94¾	Do.
	4. Main Channel from westward between Long and John's Islands	114	124	113⅓	124¾	Do.
	5. Passage between John's and Scrag Islands	60	70	59⅓	70¾	Do.
	6. Through Main Channel from westward and between Burnt Coat Island and The Sisters	37½	47½	36¾	48¼	Do.
	7. Through Main Channel from westward and between The Sisters and Crow Island	36	46	35⅓	46¾	Do.
	8. Passage between The Sisters	21	31	20⅓	31¾	Do.
	9. Passage between Black and Placentia Islands	30	40	29⅓	40¾	Do.
	From the westward by the Passage between Marshall's Island and Isle au Haut:					
	1. To eastward of Spoon Islands	66	75	65⅓	75¾	Coast Survey, 1876-'77.
	2. To westward of Spoon Islands	66	75	65⅓	75¾	Do.
	From off north end of Marshall's Island to Naskeag Point	48	57	47⅓	57¾	Do.
	Through between Green and Pond Islands into Western Channel of Blue Hill Bay	30	40	29⅓	40¾	Do.
	Up the bay to Northeast or Cranberry-Marsh Point	81	91	80⅓	91¾	Do.
	From abreast of Cranberry-Marsh Point, through Western or Blue Hill Channel, to Herriman's Point	87	97	86⅓	97¾	Do.
	From abreast of Cranberry-Marsh Point, through Eastern or Main Channel, to Herriman's Point	108	118	107⅓	118¾	Do.
	Through Eastern Channel up to Hopkins' Point	168	178	167⅓	178¾	Do.
	Through Eastern Channel up to Dog-fish Point	156	166	155⅓	166¾	Do.
	From abreast of Herriman's Point to entrance to Blue Hill Harbor	75	85	74⅓	85¾	Do.
	From abreast of Hopkins' Point to Southwest Point (Newbury Neck)	81	91	80⅓	91¾	Do.
	From abreast of Hopkins' Point to High Head (entrance to Union River Bay)	114	124	113⅓	124¾	Do.
	From abreast of Dog-fish Point to entrance to Western Bay (between Oak Point and Bartlett's Island)	84	94	83⅓	94¾	Do.
	Through Bartlett's Narrows to Western Bay (Trenton River)	42	52	41⅓	52¾	Do.
	Through passage between Bartlett's and Hardwood Islands	156	166	155⅓	166¾	Do.
	At anchorage in Rich's Cove (Outer Long Island)	30	39½	29⅓	40¼	Do.
	At anchorage in Deep Cove (Outer Long Island)	36	45½	35⅓	46¼	Do.
	At anchorage in Lunt's Harbor (Outer Long Island)	21	30½	20⅓	31¼	Do.
	At anchorage in Mackerel Cove (Burnt-Coat)	16	25	15⅓	25¾	Do.
	At anchorage in Goose Cove (Mount Desert)	14	24	13½	24¾	Coast Survey, 1872-'74.
	At anchorage in Seal Cove (Mount Desert)	19	29	18⅓	29¾	Coast Survey, 1874.
	At anchorage in Herrick's Bay	25½	34½	24¾	35¼	Do.
	At anchorage on eastern side of Moose Island	22½	32½	21¾	32¾	Do.
	At anchorage in Allen's Cove	11	21	10⅓	21¾	Do.
	At anchorage in Pretty-Marsh Harbor	13	23	12⅓	23¾	Do.
	At anchorage in Seal Cove (Bartlett's Island)	21	32	20⅓	32½	Do.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Least water in channel. Mean. High water.	Least water in channel. Spring tides. Low water.	Least water in channel. Spring tides. High water.	Authorities.
Blue Hill Bay and tributaries—Continued.	At anchorages in Western Bay:	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
	1. Between Oak Point and Alley's Island	27	37¼	26¼	37¾	Coast Survey, 1874.
	2. In Goose Cove (West Trenton)	7	17¼	6¼	17¾	Do.
	3. In Clarke's Cove	11	21¼	10¼	21¾	Do.
	4. Eastern side of Green Island	8	18¼	7¼	18¾	Do.
	At anchorage in Blue Hill Harbor:					
	1. In Outer Harbor	33	43	32¼	43¾	Do.
	2. In Inner Harbor	17	27	16¼	27¾	Do.
	At anchorage in Deep Cove (Upper Long Island)	30	40	29¼	40¾	Do.
	In entrance to McHeard's Cove	13	22	12¼	22¾	Coast Survey, 1876–'77
	In entrance to Morgan's Bay:					
	1. Between Conary's Point and Conary's Nub	23	32	22¼	32¾	Do.
	2. Between Conary's Nub and the Jed Islands*	36	45	35¼	45¾	Do.
	3. Between Newbury Neck and the Jed Islands (over bar)	10	25	15¼	25¾	Do.
	Up the bay to anchorage, off the Carrying Place	16	25	15¼	25¾	Do.
	At anchorage in the bay	24–30	33–39	23¼–29¼	33¼–39¾	Do.
	At anchorage in "The Nook" (Newbury Neck)	30	39	29¼	39¾	Do.
	In entrance to Union River Bay	96	105	95¼	105¾	Do.
	Up the bay to Union River	36	45	35¼	45¾	Do.
	In entrance to Union River	19	28	18¼	28¾	Do.
	On Sawdust Bar,† Union River	2	11	1¼	11¾	Do.
	Up the river to Ellsworth after crossing bar	1½	10½	¾	11¼	Do.
	At anchorage in Patten's Bay	18	27	17¼	27¾	Do.
Passages connecting Penobscot and Blue Hill Bays: (with harbors adjacent).	Eggemoggin Reach:					
	1. Passage from Blue Hill Bay, by Main Channel, between Calf and Mahoney's Islands and up to Channel Rock	30	39	29¼	39¾	Do.
	2. Between Mahoney's and Smuttynose	27	36	26¼	36¾	Do.
	3. Up the Reach to Benjamin River	37	46	36¼	46¾	Do.
	4. From Benjamin River to East Penobscot Bay	54	63	53¼	63¾	Coast Survey, 1874.
	5. At anchorage in Naskeag Harbor, entering from the eastward	19	28	18¼	28¾	Coast Survey, 1876–'77.
	6. At anchorage in Naskeag Harbor, entering from the Reach	11	20	10¼	20¾	Do.
	7. In entrance to Southeast Harbor	37½	46½	37	47¼	Do.
	8. In entrance to Greenlaw's Cove, south of White Island	28½	37½	28	38¼	Do.
	9. In entrance to Greenlaw's Cove, north of White Island	30	39	29¼	39¾	Do.
	10. At anchorage in Gray's Cove	2	11	1¼	11¾	Do.
	11. At anchorage in Babson's Cove	11	20	10¼	20¾	Do.
	12. At anchorage in Northwest Cove	15	24	14¼	24¾	Do.
	13. At anchorage in Centre Harbor	11	20	10¼	20¾	Do.
	14. In entrance to Benjamin River	19½	28½	18¾	29¼	Do.
	15. At anchorage in Benjamin River	19½–50	28½–59	18¾–49¼	29¼–59¾	Do.
	16. At anchorage in Stave Island Cove	10	19	9¼	19¾	Coast Survey, 1874.
	17. At anchorage in Billings' Cove	19	28	18¼	28¾	Do.
	18. In entrance to "The Punch-Bowl"	8	17	7¼	17¾	Do.
	19. At anchorage in "The Punch-Bowl"	3	12	2¼	12¾	Do.
	20. Passage between Pumpkin Island and Little Deer Island	17	26½	16¼	26¾	Coast Survey, 1873–'74
	21. In entrance to Buck's Harbor by the Eastern Passage	6	15½	5¼	15¾	Coast Survey, 1874.
	22. In entrance to Buck's Harbor by the Western Passage	5	14¼	4¼	14¾	Do.
	23. At the anchorage under Harbor Island	24	33½	23¼	36¾	Do.

* Many ledges and rocks.　　† Bar formed by deposit of slabs and sawdust from the mills at Ellsworth.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Passages connecting Penobscot **and Blue Hill Bays**: (with **harbors** adjacent).	Eggemoggin Reach—Continued.					
	24. Eastern Channel over Torry's Island Bar:					
	By Eastern Slue	15	24	14⅓	24¾	Coast Survey 1876–'77.
	By Western Slue	17	26	16⅓	26¾	Do.
	At anchorage in Southeast Harbor (Deer Isle):					
	1. Off Oceanville	18	27	17⅓	27¾	Do.
	2. Off Warren Point	25	34	24⅓	34¾	Do.
	3. In Inner Harbor	19¼	28¼	18½	29	Do.
	4. Inner Harbor off Whitmore's Neck	13	22	12⅓	22¾	Do.
	5. Passage through to "Deep Hole"	6½	15½	5¾	16¼	Do.
	6. In "Deep Hole"	102	111	101⅓	111¾	Do.
	At anchorage in Pickering's Cove	14	23	13⅓	23¾	Do.
	At anchorage in Fraser's Cove	16	25	15⅓	25¾	Do.
	At anchorage in Western Cove (Stinson's Neck)	7	16	6⅓	16¾	Do.
	At anchorage in Conary's Cove (Stinson's Neck)	9	18	8⅓	18¾	Do.
	Casco Passage:					
	1. Through from Blue Hill Bay to Eggemoggin Reach	21	30	20⅓	30¾	Do.
	2. From Blue Hill Bay to Deer Island Thoroughfare	21	30	20⅓	30¾	Do.
	3. From Blue Hill Bay to Merchants' Row	21	30	20⅓	30¾	Do.
	York Narrows: Passage through	36	45	35⅓	45¾	Do.
	Across from Burnt-Coat Island to Deer Island Thoroughfare	27	36	26⅓	36¾	Do.
	Across from Burnt-Coat Island to Merchants' Row	52	61	51⅓	61¾	Do.
	At anchorage in Buckle's Island Harbor	10	19	9⅓	19¾	Do.
	At anchorage in Seal Cove (Burnt-Coat)	14	23	13⅓	23¾	Do.
	At anchorage in Toothaker s Cove	19	28	18⅓	28¾	Do.
	At anchorage in Burnt-Coat Harbor	25	34	24⅓	34¾	Do.
	At anchorage between Burnt-Coat and Harbor Islands	23	32	22⅓	32¾	Do.
	At anchorage between Harbor and Baker Islands	21	30	20⅓	30¾	Do.
	Through Deer Island Thoroughfare:					
	1. By the South Channel, between Crotch Island and Crotch Island Ledge	15	24	14⅓	24½	Coast Survey, 1877.
	2. Through Indian Narrows, between Crotch Island Ledge and Moose Island	7	16	6⅓	16½	Do.
	At anchorage in Webb's Cove	8–14	17–23	7⅓–13⅓	17½–23½	Do.
	At anchorage off Green's Landing	20	29	19⅓	29½	Do.
	At anchorage in Mill Cove (Crotch Island)	4	13	3⅓	13½	Do.
	At anchorage in Allen's Cove (Moose Island)	4	13	3⅓	13½	Do.
	Through Saddle-Back Passage:					
	1. From entrance to Devil's Island	48	57	47⅓	57½	Do.
	2. From Devil's Island to George's Head	24	33	23⅓	33½	Do.
	3. From off George's Head to Mark Island Light-house	34½	43½	33¾	44	Do.
	Through Merchants' Row:					
	1. North of Mark Island	55½	64½	54¾	65¼	Do.
	2. South of Mark Island	54	63	53⅓	63¾	Do.
	At anchorage in Burnt Island Harbor:					
	1. Coming from the eastward	15	24	14⅓	24¾	Do.
	2. Coming from the westward	24	33	23⅓	33¾	Do.
	3. On bar separating East and West Anchorages	8	17	7⅓	17¾	Do.
	At anchorage in Merchants' Harbor	16	25	15⅓	25¾	Do.
	In Scraggy Island Passage	72	81	71⅓	81¾	Do.
	In passage between Hardwood and Merchants' Islands	55½	64½	54¾	65¼	Do.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Passages connecting Penobscot and Blue Hill Bays: (with harbors adjacent).	Anchorage on western side of Merchants' Island.	13	22	12½	22¾	Coast Survey, 1877.
	Passage into Deer Island Thoroughfare or Merchants' Row between Isle au Haut and The Fog Islands:					
	1. To eastward of Spoon Islands	60	69	59½	69¾	Do.
	2. Between the Spoon Islands	66	74	65½	74¾	Do.
	3. To westward of Spoon Islands	66	74	65½	74¾	Do.
	Passage between Burnt-Coat Island and Long Island:					
	1. North of Sister Islands	36	45	35½	45¾	Do.
	2. South of Sister Islands	42	51	41½	51¾	Do.
	Passage between Burnt-Coat and Marshall's Islands	54	63	53½	63¾	Do.
Isle au Haut (Harbors)	At anchorage in Head Harbor *	12	20¾	11½	21½	Do.
	At anchorage in Duck Harbor	10	18¾	9½	19½	Do.
	At anchorage in Moore's Harbor	21–39	30–48	20½–38½	30½–48½	Do.
	At anchorages in Isle au Haut Thoroughfare:					
	1. Below the bar	30	39	29½	39½	Do.
	2. On the bar	15	24	14½	24½	Do.
	3. Off the settlement	33	42	32½	42½	Do.
	At anchorage in Marsh Cove	12	21	11½	21½	Do.
EAST PENOBSCOT BAY (Channels).	Passage from eastward between Isle au Haut and the Fox Islands to Eagle Island:					
	1. East of Saddle-Back Ledge	75	83¾	74½	84½	Coast Survey, 1869.
	2. West of Saddle-Back Ledge	75	83¾	74½	84½	Do.
	Passage from westward between Seal Island and Three-Fathom Ledge to Eagle Island	75	83¾	74½	84½	Coast Survey, 1869–'69.
	Passage from westward between Matinicus and Wooden Ball Islands to Saddle-Back Ledge	108	116½	107½	117½	Coast Survey, 1869–'69–'69.
	Passage from westward between Matinicus and The Fox Islands	96	104½	95½	105½	Do.
	Up the bay from abreast of Eagle Island Light-house to Cape Rosier:					
	1. Through Main Channel	66	74¾	65½	75½	Coast Survey, 1873–'74.
	2. Between Eagle and Bald Islands	40½	49½	40	50	Do.
	3. Between Beach and Spruce-Head Islands	69	77¾	68½	78½	Do.
	From abreast of Cape Rosier to mouth of Penobscot River	42	51½	41½	32	Coast Survey, 1871.
EAST PENOBSCOT BAY (Harbors and Anchorages).	At anchorage in Southwest Cove (Seal Island)	30	38½	29½	39½	Coast Survey, 1866–'69.
	At anchorage in Western Bight (Seal Island)	15	23½	14½	24½	Do.
	At anchorage in Shag Roost (Seal Island)	39	47½	38½	48½	Do.
	At anchorage in Frenchman's Cove (Wooden Ball Island)	6	15½	5	16	Do.
	At anchorage in Matinicus Harbor (Matinicus)	21	29½	20¾	30½	Do.
	At anchorage in Old Cove (Matinicus)	17	25½	16¾	26½	Do.
	At anchorage in Condon's Cove (Matinicus)	8	16½	7¾	17½	Do.
	Entering from the eastward, to anchorage in Matinicus Roads	21	29½	20¾	30½	Do.
	To anchorage in Marsh Cove (Ragged Island)	14	22½	13½	23½	Do.
	To anchorage in Camp Cove (Ragged Island)	8	16½	7½	17½	Do.
	To anchorage in Indian Creek (Vinal Haven)	7	16½	6	17	Coast Survey, 1870.
	To anchorage in Roberts' Harbor (Vinal Haven)	15	24½	14	25	Do.
	To anchorage in Arey's Cove (Vinal Haven)	8	17½	7	16	Do.
	In entrance to Seal Bay (Vinal Haven):					
	1. Between Bluff Head and Hen Islands	8	17½	7	18	Coast Survey, 1871.
	2. Between Hen Islands and Long Island	37½	47	36½	47½	Do.
	At anchorage in Seal Bay	19–66	28½–75½	18–65	29–76	Do.

* Dangerous in southerly winds.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
EAST PENOBSCOT BAY (Harbors and Anchorages)—Continued.	At anchorage in Smith's Cove	9	18½	8	19	Coast Survey, 1871.
	To anchorage in Smith's Cove (Vinal Haven)	8	17½	7	18	Do.
	To anchorage in Deep Cove (Vinal Haven)	31	40½	30	41	Do.
	To anchorage in Winter Harbor (Vinal Haven)	15	24½	14	25	Do.
	At anchorage in Winter Harbor (Vinal Haven)	25	34½	24	35	Do.
	At anchorage under Fifield's Point (Deer Isle)	22½	31¼	21¾	32	Coast Survey, 1875.
	At anchorage in Burnt Cove (Deer Isle)	9	17¾	8½	18½	Do.
	At anchorage in Crockett's Cove (Deer Isle)	10	18¾	9½	19½	Do.
	At anchorage in Southwest Harbor (Deer Isle)	21	29¾	20½	30½	Do.
	To anchorage in Sylvester's Cove	13	21¾	12½	22½	Do.
	To anchorage in Carver's Cove (eastern end of Fox Islands Thoroughfare)	16	25½	15	26	Coast Survey, 1868.
	At anchorage in Mullen's Cove (North Haven Island)	9	18½	8	19	Do.
	At anchorage in Hog Island Cove (under Oak Hill, North Haven)	24	32¾	23½	33½	Coast Survey, 1873-'74.
	Over the bar between "The Porcupines" and Eagle Island	13	21¾	12½	22½	Coast Survey, 1875.
	At the anchorage between Burnt Island and Oak Hill	19	27¾	18½	28½	Coast Survey, 1873-'74.
	At anchorage under south shore of Butter Island	18	26¾	17½	27½	Do.
	At anchorage in Northwest Harbor (Deer Isle)	13½	22¼	12¾	23	Coast Survey, 1875.
	At anchorage in Northwest Slue (under Carney's Island)	14	22¾	13½	23½	Do.
	To anchorage between Eaton's and Pickering Islands (entering from eastward)	13½	22¼	12¾	23	Coast Survey, 1873-'74.
	At the anchorage	37	45¾	36½	46½	Do.
	At the anchorage in Billings' Marsh Cove	7½	16¼	6¾	17	Coast Survey, 1875.
	At the anchorage under Birch Island	18	26¾	17¼	27½	Do.
	At the anchorage under Pond Island	30	39⅓	29½	39¾	Coast Survey, 1873-'74
	At the anchorage in Weir Cove (Cape Rosier)	8	17⅓	7½	17¾	Coast Survey, 1874.
	At the anchorage in Horse-Shoe Cove (Cape Rosier)	19½	28¾	19	29¼	Do.
	At the anchorage in Orcutt's Harbor	21	30⅓	20½	30¾	Do.
	At the anchorage in Orr's Cove	24	33⅓	23½	33¾	Do.
	Entering Holbrook's Cove:					
	1. By the South channel *	20	28¾	19½	29½	Coast Survey, 1875.
	2. By the North channel	33	41¾	32½	42½	Do.
	At anchorage in Holbrook's Cove	21-34	30⅓-43⅓	20½-33½	30¾-43¾	Coast Survey, 1873.
	At anchorage in Bounty Cove (Islesboro')	11	20½	10½	21	Coast Survey, 1871.
	At anchorage in Sabbath-Day Cove (Islesboro')	11	20½	10½	21	Do.
	At anchorage in Coombs' Cove (Islesboro')	16	25½	15½	26	Do.
	At anchorage in Parker's Cove (Islesboro')	8	17½	7½	18	Do.
	Bagaduce River:					
	Entering Castine Harbor, from Dice's Head to anchorage off the town	42	51⅓	41½	51¾	Coast Survey, 1873
	Up the river to the Middle Ground	39	48⅓	38½	48¾	Do.
	Channel west of Middle Ground	66	75⅓	65½	75¾	Do.
	Channel east of Middle Ground	22	31⅓	21½	31¾	Do.
	Up the river to Trott's Ledge	30	39⅓	29½	39¾	Do.
	Main Channel south of Trott's Ledge	42	51⅓	41½	51¾	Do.
	Channel north of the ledge	19	28⅓	18½	28¾	Do.
	To anchorage off North Castine	30	39⅓	29½	39¾	Do.
	Up the river to The Narrows	27	36⅓	26½	36¾	Do.
	At anchorage in Hatch's Cove	7	16⅓	6½	16¾	Do.
	Entering Smith's Cove,† from Hospital Island to Sheep Island	22	31⅓	21½	31¾	Do.

* Dangerous; many ledges.

† Sometimes called Lawrence's Bay.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
EAST PENOBSCOT BAY (Harbors and Anchorages)—Continued.	At anchorage in Smith's Cove:					
	1. Outer anchorage	22¼	31⅝	22	32¼	Coast Survey, 1873.
	2. Upper anchorage (above Sheep Island)	16–19½	25½–28⅞	15½–19	25⅞–29¼	Do.
	At anchorage in Wadsworth's Cove	6	......	......	......	Do.
	At anchorage in Stockton Harbor	14–19½	......	......	......	Do.
Penobscot River	From abreast of Fort Point by Main Channel to Bucksport	*24	33½	23½	34	Coast Survey, 1871–'73.
	At anchorage in Fort Point Cove	16	25½	15½	25¾	Coast Survey, 1873.
	Through Eastern Channel (behind Whitmore's Island) to Bucksport	12	21½	11½	22	Do.
	At anchorage off Bucksport	75	84½	74½	85	Do.
	At Bucksport wharves	12–18	21½–27½	11½–17½	22–28	Do.
	Up river from off Bucksport to Winterport	21	34½	20	35½	Do.
	At anchorage off Winterport	27	40½	26	41½	Do.
	At Winterport wharves	12–18	25½–31½	11–17	26½–32½	Do.
	Up river from off Winterport to Crosby's Narrows	21	34⅜	20	35½	Do.
	From Crosby's Narrows to Bangor	14	27⅜	13	28½	Do.
	At anchorage below the bridge	17	30⅜	16	31½	Do.
WEST PENOBSCOT BAY (Approaches and Channels).	From eastward, by Main Channel, to abreast of Owl's Head	51	59¾	50¾	60¼	Coast Survey, 1866–'68.
	From eastward, by passage between Seal Island and Malcolm's Ledges	48	56¾	47½	57¼	Do.
	From eastward, by passage between Malcolm's Ledges and Wooden Ball Island	45	53¾	44½	54¼	Do.
	From eastward between Wooden Ball Island and Matinicus	66	74¾	65½	75¼	Do.
	From westward by Main Channel, between Matinicus and the Green Islands	66	74¾	65½	75¼	Do.
	Passage between the Green Islands	44	52¾	43½	53¼	Do.
	Passage between the Green Islands and Metinic	†45	53¾	44½	54¼	Do.
	Passage north of Metinic (Two-Bush Channel)	60	68¾	59½	69¼	Do.
	Through Muscle Ridge Channel and Owl's Head Bay to Owl's Head	30	39½	29½	40	Coast Survey, 1866–'67.
	Through Fisherman's Island Passage from Muscle Ridge Channel	26	35½	25½	36	Do.
	Up the bay from abreast of Owl's Head to Turtle Head (Islesboro')	66	75½	65½	76	Coast Survey, 1871.
	From abreast of Turtle Head to entrance to Penobscot River (Fort Point)	45	54½	44½	55	Do.
	Through the Middle Passage into East Penobscot Bay	138	147¾	187½	148½	Do.
	Across the bay from Two-Bush Channel to Fox Islands Thoroughfare	34½	43½	33¾	44½	Do.
	Across the bay from Owl's Head to Fox Islands Thoroughfare	52½	61½	51¾	61½	Do.
WEST PENOBSCOT BAY (Harbors and Anchorages).	At anchorage in Matinicus Roads	15–27	23½–35½	14¾–26¾	24½–36½	Coast Survey, 1866–'68
	At anchorage in Wheeler's Bay	19	28½	18½	29	Coast Survey, 1867.
	At anchorage in Rackliff's Bay	15	24½	14½	25	Do.
	At anchorage in Seal Harbor	24	33½	23½	34	Do.
	In entrance to Weskeag River	10½	19¾	10	20½	Coast Survey, 1873.
	At anchorage off Dyer's Point	11½	20¾	11	21½	Do.
	Up Weskeag river to South Thomaston	½	9¾	0	10½	Do.
	At anchorage in Home Harbor	24	33½	23½	34	Coast Survey, 1867.
	At anchorage in False Whitehead Harbor	10	19½	9½	20	Do.
	To anchorage in Dix Island Harbor:					
	1. Eastern Passage	9	18½	8½	19	Do.
	2. Western Passage	10½	28¾	19	29½	Do.

* At bar near Odom's Ledge.

† Greatest depth in channel (abreast of Fisherman's Island) 498 feet.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
WEST PENOBSCOT BAY (Harbors and Anchorages)—Continued.	At the anchorage in Dix Island Harbor	24	33½	23½	34	Coast Survey, 1867.
	At the anchorage under Ash Island	15	24½	14½	25	Do.
	At the anchorage off Dodge's Point (Owl's Head Bay	33	42½	32½	43	Do.
	In entrance to Carver's Harbor	27	36½	26	37	Coast Survey, 1870.
	At the anchorage off the village	7	16½	6	17	Do.
	At the anchorage in Sand Cove	7	16½	6	17	Do.
	At the anchorage in Deep Cove (Green Island)	24	33½	23	34	Do.
	Through Fox Island Reach to Hurricane Sound	15	24½	14	25	Coast Survey, 1869.
	At anchorage in Quandary Cove	14	23½	13	24	Do.
	At anchorage in Union Cove	7	16½	6	17	Do.
	At anchorage in Old Harbor	9	18½	8	19	Coast Survey, 1870.
	Through Hurricane Sound to Lairey's Narrows	81	90½	80	91	Coast Survey, 1869.
	In entrance to The Basin:					
	1. Through passage south of Barton Island	—½	9	—1½	10	Do.
	2. Through passage north of Barton Island	3	12½	2	13	Do.
	At the anchorage in The Basin	22–111	31½–120½	21–110	32–121	Do.
	Through Hurricane Sound to Leadbetter's Narrows	66	75½	65	76	Do.
	Through Lairey's Narrows to the bay	36	45½	35	46	Do.
	Through Leadbetter's Narrows to the bay	*24	33½	23	34	Do.
	To the anchorage in Long Cove	13	22½	12	23	Do.
	In entrance to Crockett's Cove	30	39½	29	40	Do.
	At the anchorage	11	20½	10	21	Do.
	In entrance to Fox Islands Thoroughfare	52	61½	51	62	Coast Survey, 1868.
	At anchorage in cove south of Brown's Head	10	19½	9	20	Do.
	At anchorage in Wooster's Cove	15	24½	14	25	Coast Survey, 1871.
	Entering Rockland Harbor:					
	1. North of South Ledge	22	31½	21	32	Coast Survey, 1863.
	2. South of South Ledge	31	40½	30	41	Do.
	At the anchorage off Crockett's Point	19½	29	18½	29½	Do.
	At the anchorage off Atlantic Point	21	30½	20	31	Do.
	At the anchorage in Broad Cove	21	30½	20	31	Coast Survey, 1871
	At the anchorage in Deep Cove	18	27½	17	28	Do.
	At the anchorage in Clam Cove (north of Rockland)	21	30½	20	31	Do.
	Over the bar between Ram Island and Brewster's Point	13	22½	12	23	Do.
	In entrance to Rockport Harbor	60	69½	59	70	Coast Survey, 1865.
	At the anchorage off the town	27	36½	26	37	Do.
	At the anchorage in Bartlett's Harbor (North Haven)	13	22½	12	23	Coast Survey, 1871.
	At the anchorage in North Harbor (North Haven)	22	31½	21	32	Do.
	In entrance to Camden Harbor:					
	1. Through Northeast Channel	19½	29¼	18¾	29¾	Coast Survey, 1865.
	2. Between Inner and Outer Ledges	22	31¾	21¼	32¼	Do.
	3. Through Main Channel	28	37¾	27¼	38¼	Do.
	4. To anchorage in Sherman's Cove	17	26¾	16¼	27¼	Do.
	5. Over Negro Island Bar	4	13½	3½	14	Do.
	At the anchorage off Easton's Point Wharf	15	24¾	14¼	25¼	Do.
	At the anchorage in Inner Harbor, off Camden	1	10¾	¼	11¼	Do.
	In entrance to Gilkey's Harbor:					
	1. Between Job's and Seven Hundred Acre Island	55	64¾	54¼	65¼	Coast Survey, 1871.
	2. Through Minot's Narrows	8	17¾	7¼	18¼	Do.
	3. By the Main Entrance from the northward under Grindel's Point	26	35¾	25¼	36¼	Do.

* Dangerous 2-feet rock nearly in mid-channel.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
WEST PENOBSCOT BAY (Harbors and Anchorages)—Continued.	Up the harbor from Minot's Island to Spruce Island	36	45¾	35½	46½	Coast Survey, 1871.
	At anchorage in Ames' Cove	9	18¾	8½	19½	Do.
	At anchorage in Cradle Cove	11	20¾	10½	21½	Do.
	At anchorage in cove east of Thrumbcap	7	16¾	6½	17½	Do.
	At anchorage off Spruce Island	32	41¾	31½	42½	Do.
	At anchorage in mouth of Broad Cove	11	20¾	10½	21½	Do.
	At anchorage between Spruce and Warren's Islands	8	17¾	7½	18½	Do.
	At anchorage under Spruce Head (Duck Trap Harbor)	31½	41¼	31¼	42	Coast Survey, 1865.
	At anchorage abreast of "The Beach" (Lincolnville)	33	42¾	32½	43½	Do.
	At anchorage in Crow Cove (South Islesboro')	14	23¾	13½	24½	Coast Survey, 1871.
	At anchorage in Saturday Cove	21	30¾	20½	31½	Coast Survey, 1865.
	At anchorage in Seal Harbor (North Islesboro')	34	43½	33½	44	Coast Survey, 1871.
	At anchorage east of Seal Island	33	42½	32½	43	Do.
	Through Hog Island Narrows	30	39½	29½	40	Do.
	At anchorage in Turtle Cove Harbor	22½	32	22	32½	Coast Survey, 1872.
	At anchorage in Sprague's Cove	8	17½	7½	18½	Do.
	To anchorage in Belfast Bay, below the town	19½	29¼	18¾	30	Do.
	Up the bay to Patterson's Point	16	25¾	15½	26½	Do.
	At the anchorage off the town	17	26¾	16½	27½	Do.
	To the anchorage off the town	13	22¾	12½	23½	Do.
	To the lower bridge	9	18¾	8½	19½	Do.
	To the upper bridge	2	11¾	1½	12½	Do.
	At anchorage in Searsport Harbor	8	17½	7½	18½	Coast Survey, 1873.
	At anchorage in Long Cove	15	24½	14½	25½	Do.
	At anchorage abreast of Mack's Point	27	36½	26½	37½	Do.
Passages connecting East and West Penobscot Bays: (with anchorages therein).	Fox Island's Thoroughfare:					
	1. In Western Entrance	58½	68¼	58	68¾	Coast Survey, 1868.
	2. In Eastern Entrance	63	72¾	62½	73½	Do.
	From eastward through the Thoroughfare to Widow's Island:					
	1. North of Channel Rock	46	55¾	45½	56½	Do.
	2. South of Channel Rock	43½	53¼	43	53¾	Do.
	From abreast of Widow's Island to Iron Point	42	51¾	41½	52½	Do.
	From abreast of Iron Point to Young's Point	19½	*29¼	19	29¾	Do.
	From abreast of Young's Point to West Penobscot Bay:					
	1. Between Brown's Head and the Sugar-Loaves	31½	41¼	31	41¾	Do.
	2. West of the Sugar-Loaves	33	42¾	32½	43½	Do.
	Through Little Thoroughfare to abreast of Calderwood's Point	18	†27¾	17½	28½	Do.
	At anchorage in Carver's Cove	16	25¾	15½	26½	Do.
	At anchorage in Kent's Cove	9–14	18¾–23¾	8½–13½	19½–24½	Do.
	At anchorage in Waterman's Cove	8	17¾	7½	18½	Do.
	At anchorage off North Haven village	21	30¾	20½	31½	Do.
	At anchorage under Zeke's Point	28	37¾	27½	38½	Do.
	At anchorage abreast of Hopkins' Point	25	34¾	24½	35½	Do.
	At anchorage in Perry's Cove	11½	21¼	11	21¾	Do.
	At anchorage in mouth of Mill River	14	23¾	13½	24½	Do.
	At anchorage in Seal Cove	10–36	19¾–45¾	9½–35½	20½–46½	Do.
	In entrance to Southern Harbor	36	45¾	35½	46½	Do.
	At anchorage abreast of Dumpling Islands	19½	29¼	19	29¾	Do
	At anchorage above Lobster Island	14	23¾	13½	24½	Do.

* Between Grindstone and Iron Point Ledges. Elsewhere not less than seven fathoms. † Dangerous.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
Passages connecting East and West Penobscot Bays: with anchorages therein.	Fox Islands Thoroughfare:	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
	At anchorage in mouth of Ames' Creek	10	19¾	9½	20¼	Coast Survey, 1868.
	At anchorage north of Crabtree Point Ledge	31½	41¼	31	41¾	Do.
	At anchorage in cove south of Brown's Head	*10	19¾	9½	20¼	Do.
	At anchorage south of Stand-in Point	*15	24¾	14½	25¼	Do.
	Passage between Eagle and North Haven Islands:					
	Through to the northward of Spoon Ledge	40½	49¾	40	50	Coast Survey, 1873–'74.
	Through to the southward of Spoon Ledge	28½	37½	28	38	Do.
	Between Oak and Burnt Islands	36	44¾	35½	45½	Do.
	Passage between Beach and Spruce Head Islands:					
	Through to the eastward of Colt's Head	36	44¾	35½	45½	Do.
	Between Colt's Head and Mark Island	69	77¾	68½	78½	Do.
	Passage between Hog and Beach Islands:					
	Through from the southward	66	74¾	65½	75½	Do.
	Through from Eggemoggin Reach	58	66¾	57½	67½	Do.
	Northern Passage:					
	Through between Cape Rosier and Pond Island	114	122¾	113½	123½	Do.
	Outside Passage between Vinal Haven and Outlying Islets:					
	1. Entering between Sheep and Carver's Islands	52	61½	51	62	Coast Survey, 1869.
	2. Between Sheep Island Ledge and Carver's Island	36	45½	35	46	Do.
	3. Between Carver's Island and Middle Ledge	46	54½	45	55	Do.
	4. Between Middle Ledge and Hay Islands	39	48½	38	49	Do.
	5. From abreast of Carver's Island into West Penobscot Bay	30	39½	29	40	Do.
Clark's Cove (near Tennant's Harbor).	In entrance north of Clark's Island Ledge	15	24½	14½	25	Coast Survey, 1867.
	In entrance south of Clark's Island Ledge	16	25½	15½	26	Do.
	At the anchorage	13	22½	12½	23	Do.
Long Cove (near Tennant's Harbor)	In entrance between Clark's Island and The Spectacles	19½	28¾	19	29½	Do.
	In entrance between The Spectacles and High Island	7	16½	6½	17	Do.
	In entrance west of Northern Island	14	23½	13½	24	Do.
	At anchorage abreast of The Spectacles:					
	1. East side	22	31½	21½	32	Do.
	2. West side	13	22½	12½	23	Do.
	At anchorage off northwest end of Clark's Island	11	20½	10½	21	Do.
	At anchorage off north end of Clark's Island	13	22½	12½	23	Do.
	At upper anchorage	6½	15¾	6	16½	Do.
Tennant's Harbor	At anchorage under Hart's Neck	16	25½	15½	26	Do.
	At anchorage off Lower Wharf	14	23½	13½	24	Do.
	At upper anchorage off the village	9	18½	8½	19	Do.
	Over the bar between Southern Island and Hart's Neck	2	11½	1½	12	Do.
Mosquito Harbor	In entrance between Mosquito Head and Mosquito Island (Main Channel)	25½	34¾	25	35½	Coast Survey, 1865.
	In entrance over bar west of Mosquito Island	9	18½	8½	19	Do.
	At lower anchorage	21	30½	20½	31	Do.
	To anchorage in Inner Harbor	9	18½	8½	19	Do.
Saint George's River (Channels).	Through passage between Mosquito Island and The Brothers to Marshall's Point	24	33½	23½	34	Do.
	From abreast of Marshall's Point between Hooper's Island and Allen's Ledge	45	54½	44½	55	Do.
	From abreast of Marshall's Point, through Herring Gut, to anchorage off South Saint George	30	39½	29½	40	Do.

* Obstructed by rocks. Not safe for strangers.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Saint George's River (Channels)—Continued.	At the anchorage off South Saint George	25½	35½	25	36½	Coast Survey, 1865.
	Over bar at northern end of Herring Gut	9	18½	8½	19	Do.
	Into Herring Gut through Passage between Gunning Rocks and Hart's Island	24	33½	23½	34	Do.
	Through Middle Channel, between Old Cilley Ledge and George's Islands:					
	1. North Passage	39	48½	38½	49	Do.
	2. Main Entrance	48	57½	47½	58	Do.
	Through between Burnt and Allen Islands to abreast of Hooper's Island	48	57½	47½	58	Do.
	Through Davis' Straits to Hooper's Island	28½	38½	28	38½	Do.
	Through South Channel (west of George's Islands) to north end of Caldwell Island	60	69½	59½	70	Do.
	Through Old Hump Channel to north end of Caldwell Island	19½	*29½	19	29½	Do.
	Through the Western Passage between Franklin and Harbor Islands to Caldwell Island	60	69½	59½	70	Do.
	Up the river to Howard's Point from abreast of south end Hooper's Island (East Channel)	30	39½	29½	40	Coast Survey, 1864.
	From abreast north end of Caldwell Island to Pleasant Point (West Channel)	76	85½	75½	86	Do.
	Through The Narrows and up to Bradford's Point	66	75½	65½	76	Do.
	From abreast of Bradford's Point to Hospital Point	21	30½	20½	31	Do.
	From Hospital Point to Thomaston	7	16½	6½	17	Do.
Saint George's River (Harbors and Anchorages)	At anchorage in George's Harbor	25–66	34½–75½	24½–65½	35–76	Do.
	At anchorage between Caldwell and Teal's Islands	30	39½	29½	40	Do.
	At anchorage under Hooper's Point	21–45	30½–54½	20½–44½	31–55	Do.
	At anchorage in Gay Cove	13	22½	12½	23	Do.
	At anchorage in Pleasant Point Gut	13	22½	12½	23	Do.
	At anchorage in Deep Cove	†21	30½	20½	31	Do.
	At inner anchorage in Deep Cove	7	16½	6½	17	Do.
	At anchorage in Turkey Cove	19	28½	18½	29	Do.
	At anchorage in Maple-Juice Cove	10–21	19½–30½	9½–20½	20–31	Do.
	At anchorage in Otis' Cove	9	18½	8½	19	Do.
	At anchorage in Watts' Cove	7	16½	6½	17	Do.
	At anchorage in Broad Cove	8	17½	7½	18	
MUSCONGUS BAY (Channels).	From eastward between Caldwell and Gay Islands (Saint George's River)	60	69½	59½	70	Coast Survey, 1865.
	From eastward through Davis' Straits	28½	37¾	28	38½	Do.
	From eastward south of Old Man Ledge	96	105½	95½	105¾	Do.
	From eastward between The Old Man and The Old Woman	46	55½	45½	56	Do.
	From eastward between The Old Woman and Allen Island	40	49½	39½	50	Do.
	Through the bay from abreast of Little Egg Rock to mouth of Meduncook River	49	58½	48½	59	Coast Survey, 1866–'67.
	Through Old Hump Channel to mouth of Meduncook River	20	29½	19½	30	Do.
	Through Western Channel from abreast of Pemaquid Point to mouth of Meduncook River	54	63½	53½	64	Do.
	Through the bay to westward of Eastern Egg Rock and Harbor Island entrance to Medomak River	39	47½	38½	48	Do.
	Through Western Channel from abreast of Western Egg Rock to mouth of Medomak River	40	48½	39½	49	Do.
	From abreast of Thief Island to entrance to Hockomock Channel	42	50½	41½	51	Do.

* Over bar abreast of "The Kegs."

† Dangerous. Rocks and kelp.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
MUSCONGUS BAY (Channels)—Continued.	From eastward to entrance to Muscongus Sound:					
	1. Between Ross and Haddock Islands	25½	34	25	34½	Coast Survey, 1867-'68.
	2. North of New Harbor Sunken Ledges	31½	40	31	40½	Do.
	3. West of New Harbor Sunken Ledges	31½	40	31	40½	Do.
	From westward from abreast of Pemaquid Point to entrance to Muscongus Sound	72	80½	71½	81	Do.
	From abreast of Thief Island, over Muscongus Bar, into Muscongus Sound	5	13½	4½	14	Do.
	At anchorage in Monhegan Harbor	33	41½	32½	42	Do.
MUSCONGUS BAY (Harbors and Anchorages).	At the anchorage between Friendship and Morse Islands	18	26½	17½	27½	Do.
	In entrance to Friendship Harbor	36	44½	35½	45	Do.
	At the anchorage off Jameson's Point	22½	31	22	31½	Do.
	At the anchorage abreast of Garrison Island	19½	28	19	28½	Do.
	To upper anchorage	3	11½	2½	12	Do.
	At upper anchorage	10	18½	9½	19	Do.
	To lower anchorage in Hatchet Cove	19½	28	19	28½	Do.
	To upper anchorage	15	23½	14½	24	Do.
	At upper anchorage	19½	28	19	28½	Do.
	At anchorage between Black and Cedar Islands	42	50½	41½	51½	Do.
	At anchorage between Hall's and Harbor Islands	22	30½	21½	31	Do.
	At anchorage between Friendship and Cranberry Islands	19½	28	19	28½	Do.
	In entrance to Marsh Harbor:					
	1. From eastward between Marsh Island and Polin's Dry Ledges	46½	55	46	55½	Do.
	2. Between Polin's South Ledge and Ross Island	43½	52	43	52½	Do.
	3. Between Ross and Haddock Islands	25½	34	25	34½	Do.
	4. From westward between Ross Island and Webber's Ledges	42	50½	41½	51	Do.
	At anchorage in Marsh Harbor	21-37½	29½-46	20½-37	30-46½	Do.
	Through the harbor into Muscongus Bay north of Marsh Island	*24	32½	23½	33	Do.
	At anchorage in Long Cove (Pemaquid)	24	32½	23½	33	Do.
	At anchorage in New Harbor (Pemaquid)	10	18½	9½	19	Do.
	At anchorage in Pumpkin Cove (Pemaquid)	25½	34	25	34½	Do.
Tributaries to Muscongus Bay (**Meduncook River**).	In entrance to Meduncook River	36	45½	35½	46	Coast Survey, 1866-'67.
	Through Otter Island Passage to entrance to the river	28	37½	27½	38	Do.
	Up the river to Crotch Island	29¼	38½	28¾	39¼	Do.
	Through Crotch Island Narrows to Bradford's Point	18	27½	17½	28	Do.
	From abreast of Bradford's Point to Upper Anchorage	8	17½	7½	18	Do.
	From off Northeast Point Reef into Friendship Harbor	15	24½	14½	25	Do.
	At anchorage in Davis' Cove	15	24½	14½	25	Do.
	At anchorage in Hornbarn Cove	7	16½	6½	17	Do.
	To anchorage west of Crotch Island †	17	26½	16½	27	Do.
	At the anchorage	19½	28¾	19	29½	Do.
	To anchorage between Friendship and Garrison Islands	15	24½	14½	25	Do.
	At the anchorage	30	39½	29½	40	Do.
	At anchorage between Crotch Island Ledges and Friendship Island	15	24½	14½	25	Do.

* Crooked and narrow.—Unobstructed channel with 12 feet.

† No passage south of Crotch Island.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Tributaries to Muscongus Bay (Medomak River).	In entrance to Medomak River by Main Channel	46½	55	46	55½	Coast Survey, 1866.
	Up river to First Divide	33	41½	32½	43	Do.
	Through Flying Passage to Jones' Point	27	35½	26½	36	Do.
	Through Hungry Island Narrows to Back River Cove	21	29½	20½	30	Do.
	Through Back River Cove to Jones' Point	21	29½	20½	30	Do.
	Up Medomak River from Jones' Point to The Narrows	30	38½	29½	39	Do.
	Through The Narrows	27	35½	26½	36	Do.
	From The Narrows to Hollis' Point	9	17½	8½	18	Do.
	From abreast of Hollis' Point to Hoffse's Point	8½	17	8	17½	Do.
	From abreast of Hoffse's Point to Waldoboro'	2	10½	1½	11	Do
	In entrance to Medomak River by Hockomock Channel	43½	52	43	52½	Do.
	Through Hockomock Channel to Jones' Point	27	35½	26½	36	Do.
	Through Lower Narrows, from Muscongus Sound into Hockomock Channel	13	21½	12½	22	Do.
	Through Keene's Narrows	(*)	8	(*)	8½	Do.
	Passage between Havenner's Point and Miller's Island†	15	23½	14½	24	Do.
	Passage between Dutch Neck and Havenner's Dry Ledge†	13	21½	12½	22	Do.
	To anchorage in Delano's Cove	10	18½	9½	19	Do.
	At the anchorage	21	29½	20½	30	Do.
	At the anchorage in Back River Cove	19½–46½	28–55	19–46	28½–55½	Do.
	In entrance to Broad Cove	24	32½	23½	33	Do.
	At anchorage in cove, abreast of Johnson's Island	39	47½	38½	48	Do.
	At inner anchorage	10	18½	9½	19	Do.
	From Broad Cove into Eastern Branch	15	23½	14½	24	Do.
	To lower anchorage in Eastern Branch	10	18½	9½	19	Do.
	At the anchorage	14	22½	13½	23	Do.
Tributaries to Muscongus Bay (Muscongus Sound).	In entrance to Muscongus Sound	72	80½	71½	81	Coast Survey, 1867–'68.
	Up the sound to abreast of Round Pond Harbor	46½	55	46	55½	Do.
	From abreast of Round Pond entrance to Muscongus Harbor	22½	31	22	31½	Do.
	Through Eastern Channel to Lower Narrows	25½	34	25	34½	Do.
	Through Lower Narrows to Medomak River	13	21½	12½	22	Do.
	Through Western Channel to Greenland Cove	12	20½	11½	21	Do.
	At anchorage in Brown's Cove	24	32½	23½	33	Do.
	At anchorage in Round Pond Harbor	11–14	19½–22½	10½–13½	20–23	Do.
	At anchorage in Muscongus Harbor	9	17½	8½	18	Do.
	At anchorage in Greenland Cove	13	21½	12½	22	Do.
	Over Muscongus Bar to Medomak River	5	13½	4½	14	Do.
John's Bay and River	In entrance to bay	156	164½	155½	165	Do.
	Up the bay to John's Island:					
	1. From the eastward	45	53½	44½	54	Coast Survey, 1867.
	2. From seaward	51	59½	50½	60	Do.
	3. From seaward west of Pemaquid Ledge	78	86½	77½	87	Do.
	Up the bay from abreast of John's Island to entrance to Pemaquid Harbor:					
	1. East of John's Island	49½	58	49	58½	Do.
	2. West of John's Island	57	65½	56½	66	Do.
	In entrance to John's River	60	68½	59½	69	Do.
	Up the river to Clarke's Point	21	29½	20½	30	Do.

* Bare before low water.

† Many ledges and rocks. Dangerous.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
John's Bay and River—Cont'd	Through "Thread of Life" Narrows:	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
	1. Between Crow and Hay Islands	42	50½	41½	51	Coast Survey, 1867.
	2. Between Hay and Birch Islands	7	15½	6½	16	Do.
	In entrance to Pemaquid Harbor	48	56½	47½	57	Do.
	At anchorage	18–37	26½–45½	17½–36½	27–46	Do.
	In mouth of Pemaquid River	21	29½	20½	30	Do.
	To lower anchorage in the river	21	29½	20½	30	Do.
	To anchorage off Coombs' Cove	9	17½	8½	18	Do.
	In entrance to McFarling's Cove	32	40½	31½	41	Do.
	Through Narrows between Davis' and Rutherford's Islands	19½	28	19	28½	Do.
	At northern anchorage in cove	25½	34	25	34½	Do.
	At southern anchorage	21	29½	20½	30	Do.
	In entrance to Robinson's Cove	40	48½	39½	49	Do.
	At lower anchorage in cove	17	25½	16½	26	Do.
	To upper anchorage	12	20½	11½	21	Do.
	At upper anchorage	13	21½	12½	22	Do.
	In entrance to Western Branch	15	23½	14½	24	Do.
	To anchorage in Western Branch	10	18½	9½	19	Do.
	In entrance to Foster's Cove	16	24½	15½	25	Do.
	At anchorage under Foster's Island	21	29½	20½	30	Do.
Damariscotta River (Channels)	In Main Entrance:					
	1. From the eastward	57	65½	56½	66	Coast Survey, 1860.
	2. From the westward	78	86½	77½	87	Do.
	In entrance through Inner Heron Island Channel	54	62½	53½	63	Do.
	In entrance through White Island Passage	60	68½	59½	69	Do.
	In entrance between Damiscove and Outer Heron Island	78	86½	77½	87	Do.
	In entrance between Damiscove and Fisherman's Island	30	38½	29½	39	Do.
	In entrance through Fisherman's Island Channel	31½	40	31	40½	Do.
	Up the river to Farnum's Point	34½	43	34	43½	Do.
	From Farnum's Point to The Narrows	42	50½	41½	51	Do.
	Through The Narrows	31½	40	31	40½	Do.
	From The Narrows to Miller's Island	42	50½	41½	51	Do.
	Through between Miller's and Carlisle Islands	51	59½	50½	60	Do.
	From Miller's Island to Merry Island	39	47½	38½	48	Do.
	From abreast of Merry Island to "The Ledges"	36	44½	35½	45	Do.
	From The Ledges to Perkins' Point	14½	23	14	23½	Coast Survey, 1860–'66.
	From off Perkins' Point to Newcastle	10	18½	9½	19	Coast Survey, 1866.
Damariscotta River (Harbors and Anchorages)	In entrance to Little River	18	26½	17½	27	Coast Survey, 1860.
	At eastern anchorage (under Reed's Island)	7	15½	6½	16	Do.
	To upper anchorage	9	17½	8½	18	Do.
	At upper anchorage	18	26½	17½	27	Do.
	In entrance to Christmas Cove	55½	64	55	64½	Do.
	At the outer anchorage	36	44½	35½	45	Do.
	To the inner anchorage	17	25½	16½	26	Do.
	At the inner anchorage	21	29½	20½	30	Do.
	At anchorage in Farnum's Cove	8	16½	7½	17	Do.
	At anchorage in Jones' Cove	9	17½	8½	18	Do.
	At anchorage off Hodgdon's Mills	24	32½	23½	33	Do.
	At anchorage in Meadow Cove	24	32½	23½	33	Do.
	At anchorage in Back Narrows	24	32½	23½	33	Do.
	At anchorage in Seal Cove	15–21	23½–29½	14½–20½	24–30	Do.
	At anchorage in Long Cove	15	23½	14½	24	Do.
	At eastern anchorage in Clarke's Cove	24	32½	23½	33	Coast Survey, 1866.
	At western anchorage in Clarke's Cove	27	35½	26½	36	Do.
	At anchorage in Pleasant Cove	14–17	22½–25½	13½–16½	23–26	Do.

Table of depths, Atlantic Coast.—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.	Least water in channel.	Least water in channel.	Least water in channel.	Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Damariscotta River (Harbors and Anchorages)—Contin'd.	At anchorage in Wadsworth's Cove	13	21½	12½	22	Coast Survey, 1860.
	In mouth of Salt-Marsh Cove	14	22½	13½	23	Do.
	At anchorage in Mears' Bight	21	29½	20½	30	Do.
	At anchorage in Fitch's Cove	13	21½	12½	22	Do.
	To anchorage in Fitch's Cove	11	19½	10½	20	Do.
	At anchorage off Newcastle	13–21	21½–20½	12½–20½	22–30	Do.
	To the anchorage	10	18½	9½	19	Do.
Booth Bay and tributaries	In entrance through Fisherman's Island Channel	31½	40	31	40½	Coast Survey, 1860.
	Channel between Damiscove and Fisherman's Island	30	38½	29½	39	Do.
	Channel east of Squirrel Island	66	74½	65½	75	Do.
	Channel west of Squirrel Island	66	74½	65½	75	Do.
	From Squirrel Island, by main channel, to McKown's Point	30	38½	29½	39	Do.
	Through channel west of Burnt Island	39	47½	38½	48	Do.
	Channel into Linekin's Bay	96	104½	95½	105½	Do.
	Channel between the Cuckolds and Cape Island	39	47½	38½	48½	Do.
	At anchorage in Damiscove Harbor	11	19½	10½	20½	Do.
	At anchorage in Squirrel Cove	39	47½	38½	48½	Do.
	At anchorage in Pig Cove	27	35½	26½	36½	Do.
	At anchorage between Burnt and Mouse Islands	30	38½	29½	39½	Do.
	At anchorage in Card's Cove	39	47½	38½	48½	Do.
	In entrance to Linekin's Bay:					
	1. Through Main Channel	96	104½	95½	105½	Do.
	2. Between Spruce Point and Spruce Point Ledges	39	47½	38½	48½	Do.
	Up Linekin's Bay to Cabbage Island	54	62½	53½	63½	Do.
	Through channel west of Cabbage Island	36	44½	35½	45½	Do.
	Up the bay to anchorage at its head	21	29½	20½	30½	Do.
	At anchorage abreast of Fish-Hawk Island	27	35½	26½	36½	Do.
	At anchorage in Lewis' Cove	21	29½	20½	30½	Do.
	At lower anchorage under north shore of Linekin's Point	45	53½	44½	54½	Do.
	At anchorage in Eastern Harbor off Town's End	19½–28½	28–37	19–28	28½–37½	Do.
	At anchorage in Mill Creek	9	17½	8½	18½	Do.
	At anchorage in Campbell's Creek	21	29½	20½	30½	Do.
	At anchorage in Western Harbor	22	30½	21½	31½	Do.
	Through Town's End Gut to Sheepscot River	21	29½	20½	30½	Do.
Sheepscot River and tributaries.	Up river to abreast of Jewett's Cove	*75	83¾	74½	84½	Coast Survey, 1858–'60.
	From abreast of Jewett's Cove to Cross River	66	74¾	65½	75½	Do.
	From off Cross River to The Narrows	54	62¾	53¾	63½	Do.
	Through The Narrows	60	68¾	59½	69½	Do.
	At anchorage in Wiscasset Bay off Wiscasset	28–33	36¾–41¾	27½–32½	37½–42½	Do.
	At anchorage in Griffith's Cove	9	17¾	8½	18½	Coast Survey, 1866.
	At anchorage between Griffith's Head and Outer Head	12	20¾	11½	21½	Do.
	At anchorage in Cape Harbor	13	21¾	12½	22½	Do.
	At anchorage in mouth of Christmas Cove	33	41¾	32½	42½	Coast Survey, 1860.
	In southern entrance to Hendrick's Harbor	25½	34¾	25	35	Coast Survey, 1866.
	In northern entrance to Hendrick's Harbor	28½	37¾	28	38	Do.
	At anchorage in the harbor	9–16	17¾–24¾	8½–15½	18½–25½	Do.
	At anchorage in Herman's Harbor	13–42	21¾–50¾	12½–41½	22½–51½	Do.
	In entrance to Herman's Harbor	25½	34¾	25	35	Coast Survey, 1860.
	In entrance to Five Island Harbor:					
	1. By the Northern or Main Channel	51	59¾	50½	60½	Coast Survey, 1866.
	2. By the Southern Passage	27	35¾	26½	36½	Do.

* Off Hendrick's Head. Not less than 21 fathoms elsewhere on this line.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Least water in channel. Mean. High water.	Least water in channel. Spring tides. Low water.	Least water in channel. Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Sheepscot River and tributaries—Continued.	To anchorage in Five Island Harbor	28½	37¼	28	38	Coast Survey, 1866.
	At the anchorage	30	38¾	29½	39½	Do.
	In entrance to Little Sheepscot River	28½	37¼	28	38	Coast Survey, 1867.
	Through Little Sheepscot to Sasanoa River	27	35¾	26½	36½	Do.
	In main entrance to Ebenecook Harbor	72	80¾	71½	81½	Coast Survey, 1866.
	In entrance north of the Green Islands	27	35¾	26½	36½	Do.
	At anchorage in the harbor	24–54	32¾–62¾	23½–53½	33½–63½	Do.
	At anchorage in eastern cove of harbor	10	18¾	9½	19½	Do.
	At anchorage in middle cove of harbor	10	18¾	9½	19½	Do.
	At anchorage in western cove of harbor	12–30	20¾–38¾	11½–29½	21½–39½	Do.
	Through Ebenecook Harbor into Town's End Gut	19½	28¼	19	29	Do.
	Passage between Boston Island and The Spectacles	10	18¾	9½	19½	Do.
	Passage between The Spectacles and Sweet's Island	36	44¾	35½	45½	Do.
	Passage between Sweet's and Ram Islands	30	38¾	29½	39½	Do.
	Passage between Sawyer's and Sweet's Islands	19½	28¼	19	29	Do.
	Entrance to Back River between Sawyer's and Barter's Islands	19½	28¼	19	29	Do.
	Through The Narrows and over bar into Back River	8	16¾	7½	17½	Do.
	Through Back River to Cross River	12½	21¼	12	22	Do.
	At anchorage in Jewett's Cove	10	18¾	9½	19½	Do.
	At anchorage in Long Cove	9	17¾	8½	18½	Coast Survey, 1858–'60.
	At anchorage in Tarbox's Cove	4	12¾	3½	13½	Do.
	At anchorage in Greenleaf's Cove	5	13¾	4½	14½	Do.
	In entrance to Cross River	61½	70¼	61	71	Do.
	Up the river to Oven's Mouth	27	35¾	26½	36½	Do.
	Through the Oven's Mouth	16	24¾	15½	25½	Coast Survey, 1866.
	At inner anchorage	30–78	38¾–86¾	29½–77½	39½–87½	Do.
	At anchorage in mouth of Parsons' Creek	30	38¾	29½	39½	Do.
	At anchorage off mouth of Back River	33	41¾	32½	42½	Coast Survey, 1858–'60.
	At anchorage in Rum Cove	8	16¾	7½	17½	Do.
	At anchorage in Colby's Cove	15	23¾	14½	24½	Do.
	At anchorage in mouth of Merrill's Cove	10	18¾	9½	19½	Do.
	At anchorage in "The Eddy"	24	32¾	23½	33½	Do.
	In mouth of Back River (Wiscasset Bay)	30	38¾	29½	39½	Coast Survey, 1866, '67
Passages connecting Sheepscot and Kennebec Rivers:—(**Sasanoa River**)	Through Goose Rock Passage to Lowe's Point:					
	1. North of Whittum Island	42	50¾	41½	51½	Coast Survey, 1867.
	2. South of Whittum Island	54	62¾	53½	63½	Do.
	From Lowe's Point through Knubble Bay	40½	49½	39¾	40¼	Do.
	From Willis' Point through Great Hell-Gate	33	*42½	32½	43	Do.
	From abreast of Bare-Neck Rock through Hockomock Bay to Hockomock Point	13	22	12½	22¾	Do.
	From abreast of Hockomock Point to Upper Hell-Gate	20	26½	19½	27	Do.
	Through Upper Hell-Gate	22½	*29	22	29½	Do.
	From Upper Hell-Gate to Preble's Point Bridge	11	17¼	10½	17¾	U. S. Engineers, 1881
	Through the bridge and into the Kennebec	22½	28½	22	29	Coast Survey, 1862.
	At anchorage in Brooks' Cove (Goose Rock)	15–27	24–36	14½–26½	24¾–36¾	Coast Survey, 1867.
	At anchorage in Newdick's Cove	14–33	23–42	13½–32½	23¾–42¾	Do.
	At anchorage in Lowe's Cove	21	30	20½	30¾	Do.
	In entrance to Robin Hood's Cove	45	53¾	44½	54½	Do.
	At outer anchorage in cove	28½	37¼	28	38	Do.
	At inner anchorage in cove	15	23¾	14½	24½	Do.
	At anchorage in Rigg's Cove	19	28	18½	28¾	Do.
	At anchorage in Dark Cove	11	20	10½	20¾	Do.

* Dangerous.—Very strong currents, especially on ebb tides.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Passages connecting Sheepscot and Kennebec Rivers:—(Sasanoa River)—Continued.	At anchorage in Round Cove	11	20	10½	20½	Coast Survey, 1867.
	At anchorage in Tarbox's Cove	19½	27½	18¾	29½	Do.
	Through the Back-door to Tyler's Island	10	19½	9½	20½	Do.
	Through the Back-door to Heal's Mills	½	10	0	11	Do.
	Through the Back-door into Hockomock Bay	7	16½	6½	17½	Do.
	Channel under Hubbard's Point to Heal's Mills	4	13½	3½	14½	Do.
	At anchorage in mouth of Hall's Bay	13½	22½	13	23½	Do.
	At anchorage in centre of Hockomock Bay	43½	52½	43	53½	Do.
	At anchorage in Hockomock Bay south of Phipps' Point	25½	34½	25	35½	Do.
	To anchorage in mouth of Brooking's Bay	13¾	22½	13	23½	Do.
	At the anchorage	19½	28½	18¾	29	Do.
	Up Montseag Bay to Westport Bridge	30	38¾	29½	39½	Do.
	Through the bridge and up to Half-Tide Rock	13	21¾	12½	23	Do.
	Through Back River, from Half-Tide Rock, to Cowseagan Narrows	18	27½	17½	28	Do.
	Through Cowseagan Narrows	27	36½	26½	37	Do.
	From the Narrows to Wiscasset Bay	18	27½	17½	28	Do.
	In entrance to Montseag Creek	9	18½	8½	19½	Do.
	At anchorage off north end of Oak Island	27	36½	26½	36¾	Do.
Sheepscot Bay	At anchorage in Stage Island Bay	16	24	15½	25	Coast Survey, 1856, '57.
	To anchorage in Sagadahoc Bay	6½	14½	6	15½	Do.
	Through between Salter's Island and Indian Point into Stage Island Bay	17	25	16½	26	Do.
Kennebec River (channels)	From eastward to abreast of Pond Island Light	33	41	32½	42	Do.
	From seaward along west shore of Seguin Island to Pond Island	*24	32	23½	33	Do.
	From westward alongshore from Casco Bay	*24	32	23½	33	Coast Survey, 1856, '57, '58.
	From abreast of Pond Island to Hunniwell's Point (west of the Sugar-Loaves)	31½	39½	31	40½	Coast Survey, 1856, '57.
	From abreast of Pond Island to Hunniwell's Point (east of the Sugar-Loaves)	31½	39½	31	40½	Do.
	From abreast of Hunniwell's Point to Parker's Head	34½	42½	34	43½	Do.
	From abreast of Parker's Head to Squirrel Point	24	30½	23½	33	Coast Survey, 1857.
	From off Squirrel Point to Bluff Head:					
	1. East of Ram Island and Pettis' Rocks	45	51	44½	51½	Do.
	2. West of Ram Island and Pettis' Rocks	36	42	35½	42½	Do.
	From Bluff Head to Fiddler's Reach	84	90	83½	90½	Do.
	Through Fiddler's Reach:					
	1. East of Lithgow's Rock (Main Channel)	78	84	77½	84½	Do.
	2. West of Lithgow's Rock	28½	†34½	28	35	Do.
	From abreast of Doubling Point to anchorage off Bath	40	46	39½	46½	Do.
	At anchorage off Bath	30–41	36–47	29½–40½	36½–47½	Do.
	From off Bath up river to Telegraph Point	25	31	24½	31½	Coast Survey, 1856, '57, '58.
	From Telegraph Point through Western Branch to "The Chops"	30	36	29½	36½	Coast Survey, 1858–'61.
	Through Eastern Branch and Burnt Jacket Channel	14	20	13½	20½	Do.
	Through Eastern Branch by Main Channel	18	24	17½	24½	Do.
	Up river from The Chops to Naumkeag Island	7	12	6½	12½	Coast Survey, 1861–'70.
	Up river from Naumkeag Island to Pittston Bridge	12½	18	12	18½	Coast Survey, 1870.

* On Pond Island Bar.

† Dangerous, on account of current.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Harbors and Anchorages in Kennebec River.	At anchorage in mouth of Heal's Eddy	7	15	6½	16	Coast Survey, 1868.
	At anchorage in Hunniwell's Cove	16	24	15½	25	Coast Survey, 1856–'57.
	At anchorage in entrance to Atkins' Bay	11	19	10½	20	Coast Survey, 1856.
	To anchorage in Parker's Head Cove	11	19	10½	20	Coast Survey, 1857.
	Through the Passage between Perkins' and Marr's Islands	39	47	38½	48	Do.
	In entrance to Back River (Arrowsic)	21	28½	20½	29½	Do.
	Up Back River to Arrowsic Bridge	8	14	7½	14½	Do.
	From the bridge to Hockomock Bay	¼	6¼	—¼	6¾	Coast Survey, 1867.
	Through Passage west of Goat Island	*10	16	9½	16½	Coast Survey, 1857.
	At anchorage in mouth of Drummore Bay	36	42	35½	42½	Do.
	Through Drummore Bay	3	9	2½	9½	Do.
	At anchorage under Lee's Island (north end of Drummore Bay)	8	14	7½	14½	Do.
	At anchorage in Fisher's Eddy	14	20	13½	20½	Do.
	In entrance to Winnegance Creek	9	15	8½	15½	Do.
	At anchorage off the Mills	7	13	6½	13½	Do.
	At anchorage in Morse's Cove	24	30	23½	30½	Do.
	In entrance to Merrymeeting Bay	17	23	16½	23½	Coast Survey, 1861.
	Through the bay to mouth of Androscoggin River	2	8	1½	8½	Do.
	Up the Androscoggin to Bay Bridge	1½	7½	1	8	Do.
	From Kennebec River through the bay to Senter's Point (mouth of Cathance River)	8	14	7½	14½	Do.
	Through the bay to mouth of Abagadusset River	†2	8	1½	8½	Do.
Coast from Seguin Island to Cape Small Point.	Passage alongshore inside of Seguin	42	50	41½	51	Coast Survey, 1856–'57, 1867.
	Passage between Seguin and Mile Ledge and up to Cape Small Point	84	92	83½	93	Coast Survey, 1856, 1867.
	Through between Cape Small Point and Fuller's or Glover's Rock	36	44	35½	45	Do.
	At anchorage in Seal Cove	‡15	23	14½	24	Coast Survey, 1867.
	At anchorage in Bald Head Cove	§16	24	15½	25	Do.
CASCO BAY (Channels)	Across the bay from Cape Small Point to Half-Way Rock	69	78	68½	78½	Coast Survey, 1854.
	From Half-Way Rock to Cape Elizabeth	57	66	56½	66½	Do.
	Through the Outside Channel from Seguin Island to Cape Elizabeth	81	90	80½	90½	Do.
	Through the Inside Passage from Cape Small Point to Portland	‖17	26	16½	26½	Do.
	Channel north of West Cod Ledge to Portland Entrance	45	54	44½	54½	Do.
	Across West Cod Ledge, between Bache Rock and West Cod Ledge Rock, to Portland Entrance.	45	54	44½	54½	Do.
	Across West Cod Ledge between the Ledge Rock and Corwin Rock	72	81	71½	81½	Do.
	Channel between Alden's and Hue and Cry Rocks	84	93	83½	93½	Do.
	From abreast of Bald Head to mouth of New Meadows River	48	57	47½	57½	Coast Survey, 1866.
	From abreast of Saddle-Back Ledge to entrance to Quohog Bay	42	51	41½	51½	Coast Survey, 1864.
	Through Casco Bay to entrance to the Gurnet	30	39	29½	39½	Do.
	From abreast of Cape Small Point to Entrance to Mericoneag Sound	54	63	53½	63½	Coast Survey, 1854.

* Over bar between Lee's and Goat Islands. Elsewhere not less than 4 fathoms.
‡ Dangerous in southerly or southeasterly winds.
‖ Over Hog Island Bar. Elsewhere not less than 21 feet.
† Over bar.
§ Dangerous in southerly winds.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
CASCO BAY (Channels)—Continued.	From abreast of Half-Way Rock, through Broad Sound, to Middle Bay	66	75	65½	75½	Coast Survey, 1863.
	From abreast of Cape Elizabeth to Luckse's Sound	54	63	53½	63½	Coast Survey, 1854.
	From abreast of Cape Elizabeth to Hussey's Sound	54	63	53½	63½	Do.
	From abreast of Cape Elizabeth to Portland Entrance	45	54	44½	54½	Do.
	Passage between Mark and Little Mark Islands	33	42	32½	42½	Do.
	Passage between Great and Little Hog Islands and Peak's Island	19	28	18½	28½	Do.
	Through White Head Passage	24	33	23½	33½	Coast Survey, 1862.
CASCO BAY (Harbors and Anchorages).	At anchorage in Wood Island Roads	30	39	29½	39½	Coast Survey, 1866.
	At anchorage in Tottman's Cove	14	23	13½	23½	Do.
	At outer anchorage in Small Point Harbor	18	27	17½	27½	Do.
	At anchorage in Inner Small Point Harbor	14	23	13½	23½	Do.
	To anchorage in Inner Small Point Harbor	3	12	2½	12½	Do.
	At anchorage in Carrying-Place Cove	21	30	20½	30½	Do.
	At anchorage in Fish-House Cove	19	28	18½	28½	Do.
	At anchorage behind Burnt-Coat Island	19½–27	28½–36	19–26½	29–36½	Do.
	At anchorage in Horse Island Harbor	19½	28½	19	29	Do.
	At anchorage in Cromwell's Cove	8	17	7½	17½	Do.
	At anchorage in Ridley's Cove	30	39	29½	39½	Coast Survey, 1864.
	At anchorage in Hen Cove	16	25	15½	25½	Do.
	At anchorage under south shore of Yarmouth Island	19½–27	28½–35¾	18¾–26½	29–36½	Do.
	At anchorage under south shore of Great Island	8	16¾	7½	17½	Do.
	At anchorage in Lowell's Cove (Orr's Island)	24	32¾	23½	33½	Do.
	At anchorage in Horse Cove (Bailey's Island)	16	24¾	15½	25½	Do.
	At anchorage between Turnip and Jaquish Islands	48	57	47½	57½	Coast Survey, 1863.
	In entrance to Potts' Harbor:					
	1. From Mericoneag Sound	16	25	15½	25½	Do.
	2. Channel west of Haskell's Island	27	36	26½	36½	Do.
	3. From Broad Sound, between Horse and Upper Flag Islands	54	63	53½	63½	Do.
	At anchorage in Potts' Harbor	21–31½	30–40½	20½–30¾	30½–41	Do.
	At anchorage in Ash Point Cove	10	19	9½	19½	Do.
	In entrance to Basin Cove	11	20	10½	20½	Do.
	To inner anchorage in Basin Cove	8	17	7½	17½	Do.
	At inner anchorage in Basin Cove	14	23	13½	23½	Do.
	At anchorage on eastern side of Upper Flag Island	27	36	26½	36½	Do.
	At anchorage under eastern shore of Crotch Island	21	30	20½	30½	Coast Survey, 1862.
	At anchorage under northern shore of Crotch Island	21–28½	30–37½	20½–27¾	30½–38	Do.
	At anchorage in Coleman's Cove	17	26	16½	26½	Do.
	In entrance to Chandler's Cove:					
	1. From eastward	31½	40½	31	41	Do.
	2. From westward	39	48	38½	48½	Do.
	At anchorage in Chandler's Cove	15–60	24–69	14½–59½	24½–69½	Do.
	At anchorage between Marsh and Overset Islands	16–34½	25–43½	15½–34	25½–44	Do.
	To anchorage in Broad Cove (Yarmouth)	14	23	13½	23½	Do.
	At anchorage in Diamond Cove	11	20	10½	20½	Coast Survey, 1868.
	At anchorage off Foster's Landing	24	33	23½	33½	Coast Survey, 1862.
	At anchorage off York's Landing	22½	31½	22	32	Do.
	At anchorage between Great Hog Island and Peak's Island	22½	31½	22	32	Coast Survey, 1868.
Tributaries of CASCO BAY (New Meadows River).	Up New Meadows River to Birch Point	39	48	38½	48½	Coast Survey, 1866.
	From abreast of Birch Point to Bragdon's Island	46½	55	46	55½	Do.

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Tributaries of CASCO BAY (New Meadows River)—Continued.	From Bragdon's to Bombazine Island	24	33	23½	33½	Coast Survey, 1866.
	From Bombazine Island to Howard's Point	12	21	11½	21½	Do.
	At anchorage in Cundiz Harbor	19–25½	28–34½	18½–25	28½–35	Do.
	At anchorage in Sandy Cove	9	18	8½	18½	Do.
	To anchorage behind Bear Island	27	36	26½	36½	Do.
	At anchorage behind Bear Island	39	48	38½	48½	Do.
	At anchorage behind Malaga Island	33	42	32½	42½	Do.
	Passage through behind Bear and Malaga Islands	21	30	20½	30½	Do.
	In entrance to "The Basin"	17	26	16½	26½	Do.
	At anchorage in "The Basin"	19½–46½	28½–55½	19–46	29–56	Do.
	At anchorage in Dingley's Cove	19	28	18½	28½	Do.
	At anchorages in Winnegance Bay;					
	1. Outer anchorage	22½	31½	22	32	Do.
	2. Inner anchorage	11	20	10½	20½	Do.
	3. Under Hen Island	21	30	20½	30½	Do.
	At anchorage in Cove behind Long Island	12–30	21–39	11½–29½	21½–39½	Do.
	At anchorage under the Three Islands	27	36	26½	36½	Do.
	In entrance to Mill Cove	15	24	14½	24½	Do.
	At anchorage under Rich's Mountain	14	23	13½	23½	Do.
	At anchorage under Merrit's Island	24	33	23½	33½	Do.
	In entrance to Broad Cove	22½	31½	22	32	Do
	At the anchorage	12	21	11½	21½	Do
	In entrance to Simons' Gurnet	14	23	13½	23½	Do.
	At anchorage under Coombs' Island	31½	40½	31	41	Do.
	At the bridge	14	23	13½	23½	Do.
	In entrance to Woodward's Cove	2	11	1½	11½	Do.
	At the anchorage	21	30	20½	30½	Do.
	At the anchorage abreast of Woodward's Point	22½	31½	22	32	Do.
	To the anchorage abreast of Woodward's Point	15	24	14½	24½	Do.
	To anchorage under Howard's Point	12	21	11½	21½	Do.
(Quohog Bay)	In entrance	42	50¾	41¼	51½	Coast Survey, 1864.
	Up the Bay to Snow's Island:					
	1. East of Pole Island	24	32¾	23¼	33½	Do.
	2. West of Pole Island	24	32¾	28¼	33½	Do.
	Through between Great and Yarmouth Islands to Ridley's Cove	21	29¾	20¼	30½	Do.
	At anchorage under Snow's Island	15	23¾	14¼	24½	Do.
	At anchorage north of Swan's Island	15	23¾	14¼	24½	Do.
	At anchorage in Orr's Cove	14	22¾	13¼	23½	Do.
(The Gurnet)	In entrance	42	50¾	41¼	51½	Do.
	Up to the bridge	8	16¾	7¼	17½	Do.
	At the usual anchorage	17	25¾	16¼	26½	Do.
(Mericoneag and Harpswell Sounds.)	Through Mericoneag Sound	55½	64½	54¾	65	Coast Survey, 1863.
	To anchorage in Mackerel Cove	30	39	29¼	39½	Do.
	Up Harpswell Sound to High Head	*24	33	23¼	33½	Do.
	From abreast of High Head to Harpswell Cove	14	23	13¼	23½	Do.
	At anchorage in Harpswell Harbor	14	23	13¼	23½	Do.
	At anchorage in Entrance to Wills' Straits	15	24	14¼	24½	Do.
	Through Wills' Straits to Horse Cove	4	13	3¼	13½	Coast Survey, 1864.
	At anchorage in Horse Cove	16	24¾	15¼	25½	Do.
	At anchorage in Clark's Cove	16	25	15¼	25½	Coast Survey, 1863.
	At anchorage in Mouth of Reed's Cove	15	24	14¼	24½	Do.
	In entrance to Mill Cove	19½	28½	18¾	29	Do.
	At anchorage in Mill Cove	15	24	14¼	24½	Do.
	In entrance to Long Cove	16	25	15¼	25½	Do.

* Off Wyer's Island Bar Elsewhere not less than 27 feet.

Table of depths, Atlantic Coast—Continued.

MAINE

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Tributaries of CASCO BAY (Mericoneag and Harpswell Sounds)—Continued	At the usual anchorage	17	26	16½	26½	Coast Survey, 1863.
	At anchorage behind Uncle Zeke's Island	16	25	15½	25½	Do.
	At anchorage in Harpswell Cove	13	22	12½	22½	Do.
	Through Prince's Gurnet to Long Reach	13	22	12½	22½	Do.
	To anchorage in Southern Arm of Long Reach	13	22	12½	22½	Do
	Through the Reach to Simon's Gurnet	10	19	9½	19½	Do
	At the anchorage off mouth of Buttermilk Cove	27	36	26½	36½	Do
(Middle Bay)	In entrance east of Whaleboat Island	60	69	59½	69½	Do.
	In entrance between Whaleboat and Little Whaleboat Islands	57	66	56½	66½	Do.
	In entrance from westward between Little Whaleboat Island and the Goose Islands	40½	49½	39¾	50	Do.
	Up the bay to Birch Island:					
	1. East of Shelter Island	33	42	32½	42½	Do.
	2. West of Shelter Island	22½	31½	21¾	32	Do.
	From abreast of Birch Island to Scrag Island	18	27	17½	27½	Do.
	From Scrag Island to Dunning's Wharf	4	13	3½	13½	Do
	At the Wharf	6½	15½	5¾	16	Do.
	At anchorage in mouth of Peter's Cove	9	18	8½	18½	Do.
	At anchorage north of The Goslings	24	33	23½	33½	Do.
	At anchorage in Birch Island Cove	7	16	6½	16½	Do.
	At anchorage in Wilson's Cove	16	25	15½	25½	Do.
(Maquoit Bay)	From Broad Sound south of Whaleboat Island	63	72	62½	72½	Do.
	Channel west of Little Whaleboat Island to abreast of Lower Goose Island	42	51	41½	51½	Do.
	From abreast of Lower Goose Island to Sister Island	27	36	26½	36½	Do.
	From abreast of Sister Island to anchorage below Bunganuc Rock	19½	28½	18¾	29	Do.
	To anchorage under Mare Point Neck	22½	31½	21¾	32	Do.
	Through Inside Passage in Casco Bay from abreast of Sand Island to French Island	28	37	27½	37½	Do.
	From abreast of French Island to Sister Island	27	36	26½	36½	Do.
	From Portland Eastern Entrance to Chebeag Point (past Chebeag Bar)	21	30	20½	30½	Coast Survey, 1862–'63.
	From abreast of Chebeag Point to Lower Goose Island (Maquoit Bay)	28½	37½	27¾	38	Do.
	From Middle Bay to Maquoit Bay:					
	1. Between Goose and Little Whaleboat Islands	49½	58½	48¾	59	Coast Survey, 1863.
	2. Between Birch and Upper Goose Islands	30	39	29½	39½	Do.
	In entrance to Mare Point Bay	19	28	18½	28½	Do.
	To the anchorage	17	26	16½	26½	Do.
	At the anchorage	19	28	18½	28½	Do.
(Freeport River)	In entrance between French and Great Moshier's Island	22½	31½	22	32	Coast Survey, 1862.
	From Moshier's Ledge to Bowman's Island	22½	31½	22	32	Do.
	From Bowman's Island through The Narrows to Strout's Point Wharf	21	30	20½	30½	Do.
	From abreast of Strout's Point to Bartol's Island	4	13	3½	13½	Do.
	From abreast of Strout's Point to Bartol's Point	6	15	5½	15½	Do
	To anchorage west of Flying Point Neck	11	20	10½	20½	Do
	At anchorage between the Moshier Islands and Cousin's Island	21	30	20½	30½	Do.
(Yarmouth River)	Through Hussey's Sound to Sandy Point Ledges	22	31	21½	31½	Do.
	From abreast of Sandy Point Ledges to Brown's Point	9	18	8½	18½	Do.
	From abreast of Brown's Point to Yarmouth Falls	4	13	3½	13½	Do

Table of depths, Atlantic Coast—Continued.

MAINE.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Tributaries of CASCO BAY (Portland Harbor).	From Portland Head Light-house to Breakwater Light-house	21	30	20½	30½	Coast Survey, 1854.
	Channel south of Middle Ground	19	28	18½	28½	Coast Survey, 1868.
	Between Middle Ground and wharves	19	28	18½	28½	Coast Survey, 1869.
	To Portland, Saco and Portsmouth Railroad Bridge	19	28	18½	28½	Do.
	To Vaughan's Bridge	16	25	15½	25½	Do.
	To upper Railroad Bridge	14	23	13½	23½	Do.
	To Westbrook Bridge	4	13	3½	13½	Do.
	At anchorage in the harbor	21	30	20½	30½	Do.
	To anchorage in Hog Island Roads	24–39	33–48	23½–38½	33½–48½	Coast Survey, 1867.
	Channel to Railroad Bridge	19	28	18½	28½	Do.
	Channel to Tukey's Bridge	15	24	14½	24½	Coast Survey, 1854.
	Channel to Back Cove Wharf	1	10	½	10½	Coast Survey, 1869.
	Channel to Martin's Point Bridge (Presumpscot River)	8	17	7½	17½	Coast Survey, 1868.
	Channel to Casco Iron Works	6	15	5½	15½	Do.
	To Cape Elizabeth wharves	3	12	2½	12½	Coast Survey, 1854.
Harbors on Cape Elizabeth Shore.	At anchorage in Seal Cove:					
	1. Northeast of Seal Rocks	24	33	23¼	34	Coast Survey, 1850.
	2. Southwest of Seal Rocks	14	23	13¼	24	Do.
	Richmond's Island:					
	To anchorage in Broad Cove	10	19	9½	20	Do.
	To anchorage in Muscle Cove	21	30	20¼	31	Do.
	To anchorage in Richmond's Island Harbor west of Breakwater	24	33	23¼	34	Do.
Saco Bay (Harbors and Anchorages).	To anchorage off mouth of Saco River	21	29½	20¼	31	Do.
	To anchorage under Prout's Neck	22	30½	21¼	32	Do.
	In entrance to Wood Island or Winter Harbor:					
	1. Between Wood Island and Gooseberry Island	13	21½	12	22¼	Coast Survey, 1871.
	2. Between Wood Island and Stage Island	16	24½	15	25¼	Do.
	3. Between Stage Island and Basket Island	3	11½	2	12¼	Do.
	To anchorage abreast of "Biddeford Pool" Village	16	24½	15	25¼	Do.
	In entrance to Biddeford Pool	6¼	14¾	5	15½	Do.
	In entrance to Saco River between Ram Island and Ram Island Ledge	17¼	25¾	18½	26½	Coast Survey, 1866.
	Passage north of Basket Island	7½	16	6½	17¾	Do.
	Passage between Ram Island and Sharp's Rock	12	20½	11	21¼	Do.
	Up river to Jordan's Pier	2½	11	1½	11¾	Coast Survey, 1867.
	From Jordan's Pier to Chandler's Point	6½	15	5½	15¾	Do.
	From Chandler's Point to Johnson's Wharf	3¾	12¼	2¾	13	Do.
	From Johnson's Wharf to Potter's Pier	9	17½	8	18¼	Do.
	From Potter's Pier to Thunder Island	6½	15	5½	15¾	Do.
	From Thunder Island to Factory Island	3¼	11¾	2¼	12½	Do.
Stage Island Harbor	Passage around Seal Rocks	7¼	15¾	6	16½	Coast Survey, 1871.
	To anchorage	8	16½	7	17¼	Do.
Cape Porpoise Harbor	Entrance north of Old Prince Ledge	19	25	18¼	25¾	Do.
	Entrance south of Old Prince Ledge	24	30	23¼	30¾	Do.
	To anchorage below Light-house	18	24	17¼	24¾	Do.
	To anchorage above Light-house	12	18	11¼	18¾	Do.
Kennebunk River	From entrance to anchorage	4	10	3¼	10¾	U. S. Engineers, 1881.
Cape Neddick Roads	To anchorage	22½	28½	21¾	29¼	Coast Survey, 1853.
Cove north of Cape Neddick	do	21	27	20¼	27¾	Do.
Cove south of Cape Neddick	do	18	24	17¼	24¾	Do.

Table of depths, Atlantic Coast—Continued.

MAINE, NEW HAMPSHIRE, AND MASSACHUSETTS.

Places.	Limits between which depths are given	Least water in channel. Mean. Low water.	Least water in channel. Mean. High water.	Least water in channel. Spring tides. Low water.	Least water in channel. Spring tides. High water.	Authorities.
		Feet.	Feet.	Feet.	Feet.	
York River	Channel to Rock's Nose	13	21	12	22	Coast Survey, 1853.
	Channel to Barrell's Wharf	8	16	7	17	Do.
	Channel to Dennett's Wharf	7	15	6	16	Do.
	To anchorage in York River Harbor	10	18	9	19	Do.
Portsmouth Harbor (New Hampshire).	From Whale's Back to Fort Washington	42	50½	41¼	51¼	Coast Survey, 1851-'57.
	From Fort Washington to The Bridge	36	44½	35¼	45¼	Do.
	Off the City Wharves	63	71½	62¼	72¼	Do.
	Passage through Little Harbor to Sagamore Creek	3	11½	2¼	12¼	Do.
	Passage to Sagamore Creek Bridge	1	9½	¼	10¼	Do.
	To anchorage in Little Harbor	9¾	18	9	18¾	Do.
	To anchorage in Spruce Creek:					
	1. Below Kittery Bridge	28¾	37	28	37¾	Do.
	2. Above Kittery Bridge	21	29½	20¼	30¼	Do.
	To anchorage in Pepperell's Cove	7¾	16	7	16¾	Do.
Isles of Shoals (Maine and New Hampshire).	Passage between Hog Island and Smutty Nose	24	32½	22¼	33¼	Coast Survey, 1874.
	Passage east of Lunging Island	54	62½	53¼	63¼	Do.
	Passage west of Star Island	83	41½	82¼	42¼	Do.
	Passage between Star and Cedar Islands	6	14½	5¼	15¼	Do.
	To anchorage in Gosport Harbor	21-51	29½-50½	20¼-50¼	30¼-60¼	Do.
Rye Harbor	To anchorage	3	11	2¼	11¾	Coast Survey, 1870.
Cove south of Rye Ledge	do	18	26	17¼	26¾	Do.
Cove south of Great Boar's Head.	do	9	17	8¼	17¾	Do.
Hampton Harbor and River (Massachusetts)	From Old Cellar Rock to Town Rocks	*4	11¾	3¼	12½	Do.
	At the anchorage	5	12¾	4¼	13½	Do.
Newburyport Harbor	Over the Bar	*4	11¾	3¼	12½	L't.-House Board, 1881
	Channel to Town Wharves	12	19¾	11¼	20½	Do.
Ipswich Bay and tributaries	Channel to Ipswich River	*5	13½	4½	14	Coast Survey, 1852.
	At anchorage beyond Breakers	9	17½	8½	18	Do.
	At anchorage in Plum Island Sound under Great Neck	19¼	27½	18¾	28	Do.
	To the anchorage	13	21	11¾	21½	Do.
	In entrance to Essex River over bar	*6	15	5	16	Coast Survey, 1856.
	At the anchorage in Essex River	21	30	20	31	Do.
	In Channel over Annisquam Bar to Jones River	*6½	15½	5½	16½	Do.
	At the anchorage abreast of the Village	21	30	20	31	Do.
Pigeon Cove	To anchorage	7	15½	6	16½	Coast Survey, 1857.
Rockport Harbor	In main entrance to Harbor	15	23½	14	24½	Do.
	To wharves	5	13½	4	14½	Do.
	At anchorage inside Breakwater	11	19½	10	20½	Do.
	At anchorage in Sandy Bay	18	26½	17	27½	Do.
	Over bar, from Westward, between Gap Head and Straitsmouth Island	3	11½	2	12½	Do.
	From the Southward over Milk Island Bar	7½	16	6½	16¾	Coast Survey, 1873.
	Between Straitsmouth Island and Avery's Ledge	34	42½	33	43½	Coast Survey, 1857.
Whale Cove	To anchorage	11	19½	10	20½	Do.
Loblolly Cove	do	13	21½	12	22½	Do.
MASSACHUSETTS BAY (Harbors and Anchorages)	Brace's Cove:					
	At anchorage	7	16	6¼	16¾	Coast Survey, 1853.
	Gloucester Harbor:					
	Up the harbor to Ten Pound Island Light-house	30	39	29¼	39¾	Do.
	From Ten-Pound Island Light-house to Fort Point	19	28	18¼	28¾	Do.
	From Fort Point to Spindle on Five-Pound Island	3	12	2¼	12¾	Do

* Shifting bar.

Table of depths, Atlantic Coast—Continued.

MASSACHUSETTS.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
MASSACHUSETTS BAY (Harbors and Anchorages)—Continued.	Gloucester Harbor—Continued:	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
	At Upper Wharves	1	10	¼	10¾	Coast Survey, 1853.
	At anchorage on north side of Dog Bar	18	27	17¼	27¾	Do.
	At anchorage in Light-house Cove	6	15	5¼	15¾	Do.
	At Wharf in Light-house Cove	4	13	3¼	14	Do.
	At anchorage in Southeast Harbor	21–28	30–37	20¼–27¼	30¾–37¾	Do.
	At anchorage in Inner Harbor	13–22½	22–31½	12¼–21¾	22¾–32¼	Do.
	At anchorage in Smith's Cove	12–16	21–25	11¼–15¼	21¾–25¾	Do.
	At anchorage in Western Harbor	18–25½	27–34½	17¼–24¾	27¾–35¼	Do.
	At anchorage in Fresh Water Cove	8–15	17–24	7¼–14¼	17¾–24¾	Do.
	Kettle Cove:					
	To anchorage	10	19	9¼	19¾	Do.
	Salem Harbor:					
	Through Main Ship Channel to Bowditch's Ledge Beacon	42	51¼	41¼	52	Coast Survey, 1850–'51.
	Through Main Ship Channel to Little Haste Beacon	21	30¼	20¼	31	Do.
	Through Cat Island Channel to Little Haste Beacon	25	34¼	24¼	35	Do.
	Through Western Channel past Marblehead Rock	25	34¼	24¼	35	Do.
	From abreast of Little Haste Beacon to Naugus Head	25	34¼	24¼	35	Do.
	From abreast of Naugus Head to Lower Wharf	5	14¼	4¼	15	Do.
	At east end of Derby Wharf	2	11¼	1¼	12	Do
	To anchorage abreast of Fort Pickering Light-house	25	34¼	24¼	35	Do.
	At anchorage in Inner Harbor	21	30¼	20¼	31	Do.
	Channel to Beverly Entrance	*19	28¼	18¼	29	Do.
	At anchorage in Beverly Harbor	15–18	24¼–27¼	14¼–17¼	25–28¼	Do.
	At anchorage in Manchester Roads	21–40½	30¼–49¾	20¼–39¾	31–50½	Do.
	Marblehead Harbor:					
	In the entrance	28	37	27	38	Do.
	At the anchorage	13–21	22¼–30¼	12¼–20¼	23–31	Do.
	Nahant Bay:					
	At the anchorage	11–42	20¼–51¼	10¼–41¼	21–52	Coast Survey, 1858.
BOSTON BAY (Harbors and Anchorages).	To anchorage in Broad Sound at mouth of Lynn Harbor	9	18¼	8¼	19	Do.
	Lynn Harbor:					
	Channel to Sands' Point	6	15¼	5¼	16	Do.
	Channel to Pines Point	3	12¼	2¼	13	Do.
	Channel to Railroad Bridge	2	11¼	1¼	12	Do.
	At the anchorage	7	16¼	6¼	17	Do.
	Boston Harbor (Channels):					
	From the southward from off Harding's Ledge through Main Ship Channel to Boston Light-house	30	39¼	29	40	Coast Survey, 1867.
	From abreast of Boston Light-house through Main Ship Channel to the city	22½	31¾	21½	32½	U. S. Engineers, 1879.
	Through "The Narrows" (Main Ship Channel)	25	34½	24	35¼	Coast Survey, 1867.
	Through Main Ship Channel to anchorage in President's Roads	22½	31¾	21½	32½	Do.
	Through Main Ship Channel to anchorage in Nantasket Roads	21	30½	20	31¼	Do.
	Passage in Main Ship Channel north of the Lower Middle	19	28½	18	29¼	Do.

* Very narrow and crooked.

Table of depths, Atlantic Coast—Continued.

MASSACHUSETTS.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
	Boston Harbor (Channels)—Continued:	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
BOSTON BAY (Harbors and Anchorages)—Continued.	Through Hypocrite Channel as far as Little Calf Island	49	58½	48	59½	Coast Survey, 1867.
	Through Hypocrite Channel to South Channel of Broad Sound	19	28½	18	29½	Do.
	Through South Channel of Broad Sound to Boston	20	29½	19	30½	Do.
	Through North Channel of Broad Sound to Boston	11	20½	10	21½	Do.
	Through Back or Western Way	9	18½	8	19½	Do.
	Through Black Rock Channel from Narrows Light-house to Hypocrite Channel	24	33½	23	34½	Do.
	Through Governor's Island Channel	19	28½	18½	29½	Do.
	To East Boston Wharves through Governor's Island Channel	9½	18½	8½	19½	Do.
	Through Shirley Gut	13	22½	12	23½	Do.
	Through Sculpin Ledge Channel	11	20½	10	21½	Do
	Through Fort Hill Channel into South Bay	7½	17½	6½	18	Do.
	To East Boston Wharves by the passage north of Noddles Island Flats	2	11½	1	12½	Do.
	From Boston Wharves to Charlestown Wharves	30	39½	29½	40½	Do.
	Between East Boston and Charlestown to Chelsea Bridge	19	28½	18½	29½	Do.
	Between East Boston and Charlestown to Chelsea River Bridge	5	14½	4½	15½	Do.
	Through Nantasket Gut into Hingham Bay	33	42½	32	43½	Do.
	At anchorage in Hingham Bay	19–48	28½–57½	18–47	29½–58½	Do.
	To anchorage abreast of Sailor's Island, Hingham Harbor	15	24½	14	25½	Do.
	At the anchorage abreast of Sailor's Island	19	28½	18	29½	Do.
	To Lower Wharves, Hingham Harbor	4½	14	3½	14½	Do.
	To Hampton Hill, Weir River	11	20½	10	21½	Do.
	To East Neck Wharf, Weymouth Back River	7	16½	6½	17½	Coast Survey, 1869.
	To County Bridge, Weymouth Fore River	11	20½	10½	21½	Do.
	To Weymouth Landing, Weymouth Fore River	5	15	4½	15½	Do.
	To Phillips' Head, Town River Bay	10	19½	9	20½	Do.
	To anchorage in Quincy Bay	7	16½	6	17½	Do.
	To Savin Hill, Neponset River	9	18½	8	19½	Coast Survey, 1867.
	To Neponset Bridge, Neponset River	7	16½	6	17½	Do.
	To Quincy Railroad pier, Neponset River	3	12½	2	13½	Do.
	Charles River, from entrance to Long Bridge	16	25½	15½	26½	Do.
	Charles River, from entrance to Brookline Bridge	5½	15½	4½	16	Do.
	Mystic River, from entrance to Boston and Maine Railroad Bridge	8	17½	7½	18½	Do.
	To anchorage in Cohasset Harbor	8	17½	7	18½	Do.
Plymouth Harbor	From entrance to Duxbury Pier Light-house	24	33½	23½	34	Coast Survey, 1870.
	Through Goose Point Channel to anchorage near High Cliff	12	21½	11½	22	Do.
	Through Main Channel to abreast of town wharves	13	22½	12½	23	Do.
	Up to Long Wharf	1½	10½	½	11½	Do.
	At the anchorage between Gurnet Point and Saquish Head	10	19½	9	20½	Do.
	Channel to Captain's Hill Wharf, Kingston Bay	9	18½	8½	19	Do.
	Channel to mouth of Jones' River, Kingston Bay	3	12½	2½	13	Do.
	From Duxbury Pier Light-house to Clark's Island, Duxbury Bay	15	24½	14½	25	Do.
	At anchorage under Clark's Island	26	35½	25½	36	Do.
	Channel to Powder Point, Duxbury Bay	7	16½	6½	17	Do.
	To anchorage in "Cow Yard", Duxbury Bay	21	30½	20	31½	Do.
	At anchorage abreast of Duxbury	15–23	24½–32½	14–22	25½–33½	Do.

Table of depths, Atlantic Coast—Continued.

MASSACHUSETTS.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tide.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Plymouth Harbor—Continued.	To anchorage in Warren's Cove	13	22½	12	23½	Coast Survey, 1870.
Barnstable Harbor	Over the bar*	7½	16¾	6¾	17½	Coast Survey, 1861.
	Channel to Red Rock	6½	15⅛	5⅛	16½	Do.
	Channel to Calves-Pasture Point	½	9¾	— ½	10½	Do.
	Anchorage off Sandy Neck Light-house	14–36	23½–45½	13½–35½	24–46	Do.
Wellfleet Harbor	Over outer bar*	8	19	6¾	20	Do.
	Over inner bar	11	22½	9¾	23	Do.
	To Mayo's Rocks	7	18½	5¾	19	Do.
	To anchorage behind Billingsgate Shoal	24	35½	22¾	36	Do.
	To anchorage outside lower bar	17	28½	15¾	29	Do.
	To anchorage between the bars	15	26½	13¾	27	Do.
	To anchorage above Billingsgate Light-house	27	38½	25¾	39	Do.
Provincetown Harbor	To anchorage	36–60	45½–69½	35½–59½	46–70	Coast Survey, 1868.
NANTUCKET AND VINEYARD SOUNDS (Channels).	Through North Channel into Butler's Hole between Pollock Rip and its Broken Part	21	24¾	20⅛	25¾	Coast Survey, 1872.
	Through North Channel into Butler's Hole from Pollock Rip Light-vessel to Shovelful Light-vessel	24	27¾	23⅛	28¾	Do.
	Passage between Broken Part of Pollock Rip and Twelve Feet Shoal to Pollock Rip Light-vessel	19	22¾	18⅛	23¾	Do.
	Through North Channel from Shovelful Light-vessel to Handkerchief Light-vessel	45	48¾	44⅛	49¾	Do.
	Through North Channel from Handkerchief Light-vessel to Bishop and Clerk's Light-house	22	25	21¾	25⅛	Do.
	Through North Channel from Bishop and Clerk's Light-house to Succonesset Shoal Light-vessel	19	20¾	18¾	21	Do.
	Through North Channel from Succonesset Shoal Light-vessel to Nobska Point Light-house	21	22¾	20¾	23	Do.
	From Nobska Point through Vineyard Sound	52	54¾	51⅛	56	Do.
	Through Beach Channel into Butler's Hole	18⅛	22½	18	23½	Do.
	Through Beach Channel around Monomoy Point	13	16¾	12⅛	17¾	Do.
	Through Main Channel to Cross Rip Light-vessel	26	29⅛	25⅛	30	Do.
	From Cross Rip Light-vessel to West Chop Light-house	42	43¾	41¾	44	Do.
	Through from Handkerchief Light-vessel to Cross Rip Light-vessel	27	30	26¾	30⅛	Do.
	Through Middle Channel (between L'Homme Dieu Shoal and "The Hedge Fence")	21	22¾	20¾	23	Do.
	Through Middle Channel from Succonesset Shoal Light-vessel to Nobska Point	21	22¾	20¾	23	Do.
	Through Muskeget Channel:					
	1. By the Main Passage	19	20	18	21	Coast Survey, 1851.
	2. Between Wasque Bluff and Skiff Island	19	20¾	18¾	21	Do.
	3. Between Muskeget Rock and Mutton Shoal	15	16¾	14¾	17	Do.
	4. Between Norton's Shoal and Long Shoal	22	23¾	21¾	24	Do.
NANTUCKET AND VINEYARD SOUNDS (Harbors and Anchorages).	Into Chatham Roads from Butler's Hole by the passage between Monomoy Point and "The Handkerchief"	22	25¾	21⅛	26¾	Coast Survey, 1872.
	At anchorage in Chatham Roads	19–33	22¼–36¾	18⅛–32⅛	23¼–37¼	Coast Survey, 1874.
	Over the bar into Stage Harbor	3	6¾	2⅛	7½	Do.
	At the anchorage in Stage Harbor	12	15¾	11⅛	16½	Do.
	At anchorage in Bass River Roads under Breakwater	8	11¾	7¾	12½	Coast Survey, 1872.
	At outer anchorage	18	21¾	17¾	22½	Do.
	Over bar into Nantucket Harbor to Brant Point Light-house	4	7	3¾	7½	Atlantic Coast Pilot.

*Shifting sand-bar.

Table of depths, Atlantic Coast—Continued.

MASSACHUSETTS.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
NANTUCKET AND VINEYARD SOUNDS (Harbors and Anchorages).	From inside bar to Nantucket wharves	11	14	10¾	14¼	Coast Survey, 1846.
	Through channel from Lower Harbor to Middle Harbor	6	9	5¾	9¼	Do.
	Through channel from Middle Harbor to Upper Harbor*	5	8	4¾	8¼	Do.
	At anchorage in Upper Harbor	21–22½	24–25½	20¾–22¼	24¼–25¾	Coast Survey, 1872.
	In entrance to Matacut Harbor	7½	10½	7¼	10¾	Coast Survey, 1854.
	At the anchorage	12	14¾	11¾	15	Do.
	At anchorage in Hyannis Roads under Breakwater	16	19½	15½	19½	Coast Survey, 1872.
	To railroad wharf at Hyannis Port	7	10½	6½	10¼	Do.
	At anchorage just to westward of Breakwater	13	16½	12½	16¼	Do.
	Into Lewis' Bay	3	6¼	2½	6¼	Do.
	At anchorage in Lewis' Bay	10–13	13¼–16¼	9½–12½	13¼–16¼	Do.
	Through between Hodges' Rock and Southwest Ground	16	19¼	15½	19¼	Do.
	Through East Channel into Centreville Harbor	10	13¼	9½	13¼	Atlantic Coast Pilot, 1880.
	At the anchorage	18–19½	21¼–22¾	17½–19	21¼–23	Do.
	Through West Channel	10	13¼	9½	13¼	Do.
	At anchorage in Deep Hole (Osterville)	7–9	10¼–12¼	6½–8½	10½–12½	Do.
	From entrance to anchorage in Edgartown Outer Harbor	21	23	20¾	23¼	Coast Survey, 1871.
	Over bar to Inner Harbor and anchorage	13	15	12¾	15¼	Do.
	Through from Inner Harbor to Cotamy Point	8	10	7¾	10¼	Do.
	To anchorage in Cotamy Bay	7	9	6¾	9¼	Do.
	From Cotamy Bay into Mattakeset Bay	3	5	2¾	5¼	Coast Survey, 1860.
	To anchorage in Outer Roads of Vineyard Haven	19½	21½	19½	21½	Coast Survey, 1871.
	To anchorage off Holmes' Holl Village	9½	11½	9½	11½	Do.
	Through main channel of Wood's Holl to anchorage in Great Harbor	15–36	16½–37½	14¾–35¾	17–38	Atlantic Coast Pilot, 1880.
	Through channel into Buzzard's Bay	14	15½	13¾	16	Coast Survey, 1845.
	Into Little Harbor	10	11½	9¾	12	U. S. Engineers, 1880.
	Into Hadley's Harbor	14	18	13½	18½	Coast Survey, 1845.
	Into Hadley's Harbor and up to wharf	6	10	5½	10½	Do.
	Passage between Grassy Island and Red Ledge	9	10½	8¾	11	U. S. Engineers, 1880.
	To anchorage in Tarpaulin Cove	14–30	16½–32½	13¾–29¾	16½–32½	Coast Survey, 1845.
	Through Robinson's Holl into Buzzard's Bay	14	15½	13¾	16	Do.
	Through Quick's Holl into Buzzard's Bay	28	31¾	27½	32¼	Do.
BUZZARD'S BAY (Channels).	From off Hen and Chickens Light-ship to abreast of Wing's Neck Light-house	22	25¾	21½	26½	Do.
	From Hen and Chickens Light-ship to Dumpling Rocks Light-house (New Bedford Entrance)	24	27¾	23½	28¼	Do.
BUZZARD'S BAY (Harbors and Anchorages).	New Bedford Harbor:					
	To Clark's Point Light-house	22	25¾	21½	26¼	Do.
	To Butler's Flats	19	22¾	18½	23¼	Do.
	To Palmer's Island Light-house	16	20½	15½	20½	Do.
	To Pope's Bridge	9	13¼	8½	13½	Do.
	To the New Bedford wharves	7	11½	6½	11½	Do.
	To head of Clark's Cove	9	12¾	8½	13¼	Do.
	At usual anchorage in Clark's Cove	13–18	16¾–21¾	12½–17½	17¼–22¼	Do.
	At anchorage in Padanaram Harbor	7–12	10¾–15¾	6½–11½	11¼–16¼	Do.
	Mattapoiset Harbor:					
	Through Mattapoiset Harbor to Ned's Point Light-house	13	16¾	12½	17½	Do.
	At anchorage off Ned's Point	7	20¾	16½	21½	Do.
	At anchorage off the village	12	15¾	11½	16½	Do.
	To anchorage in Aucoot Cove	14	17¾	13½	18½	

* Many shoals between Middle and Upper Harbors.

Table of depths, Atlantic Coast—Continued.

MASSACHUSETTS AND RHODE ISLAND.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Least water in channel. Mean. High water.	Least water in channel. Spring tides. Low water.	Least water in channel. Spring tides. High water.	Authorities.
BUZZARD'S BAY (Harbors and Anchorages).	Sippican Harbor:	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
	Through the harbor to Ram Island	13	17¼	12½	17½	Coast Survey, 1866.
	To Nye's wharf	12	16¼	11½	16½	Do.
	To Sippican wharf	6	10¼	5½	10½	Do.
	To Bush Rocks	3	7¼	2½	7½	Do.
	At inner anchorage	10	14¼	9½	14½	Do.
	Up Wareham River to Swift's Neck	10	14¼	9½	14½	U. S. Engineers, 1879.
	To the town of Wareham	9	13¼	8½	13½	Do.
	Up Weweantic River to the bridge	7	11¼	6½	11½	Coast Survey, 1845.
	Through Cohasset Narrows from Wing's Neck Light-house to Hog Neck	12	16¼	11½	16½	Do.
	From Wing's Neck Light-house to Onset Island	9	13¼	8½	13½	Do.
	In entrance to Cataumet Harbor	19	23¼	18½	23½	Do.
	At the anchorage	13–18	17–22¼	12–17½	17½–22½	Do.
	Up Pocasset Harbor to abreast of Pocasset village.	6	10¼	5½	10½	Do.
	At anchorage in outer harbor	10–18	14¼–22¼	9½–17½	14¼–22½	Do.
	From Pocasset Harbor into Red Brook Harbor	11	15¼	10½	15½	Do.
	Passage south of Bassett's Island	3	7¼	2½	7½	Do.
	To anchorage in Wild Harbor	15	19¼	14½	19½	Do.
	To anchorage in Quamquisset Harbor	9	13¼	8½	13½	Do.
	To anchorage in Cuttyhunk Harbor	19	22	18¾	22¾	Do.
	To anchorage in Westport Harbor	8	12	7¾	12¼	Coast Survey, 1839.
	Sakonnet River:					
	From entrance to Mount Hope Bay	20	24	19½	24¼	Coast Survey, 1848–'61.
	To anchorage in Church's Cove	13	17	12½	17¼	Coast Survey, 1848.
	To anchorage in Nannaquacket Pond	19	23	18½	23¼	Coast Survey, 1861.
	In entrance to "The Cove"	11	15	10½	15¼	Do.
	At anchorage in "The Cove"	3½	7½	3	7¾	Do.
NARRAGANSETT BAY (Channels).	Through Eastern Passage from Brenton's Reef Light-ship to Conimicut Light-house	22½	26¾	22	27	Coast Survey, 1868.
	Through Western Passage from Point Judith Light-house to Conimicut Light house	17	21¼	16½	21½	Do.
	Through the Middle Passage, between Conanicut and Prudence Islands	19½	23¾	19	24	Do.
	Through the Passage between Prudence and Patience Islands	7	11½	6½	12	Do.
NARRAGANSETT BAY (Harbors and Anchorages).	Newport Harbor:					
	Through the Southern Entrance to anchorage in Newport Harbor	15	19	14½	19¼	Do.
	To anchorage through the Northern Entrance	21	25	20½	25¼	Do.
	To anchorage in Brenton's Cove	15	19	14½	19¼	Do.
	To anchorage in Mackerel Cove	12–22½	16–26½	11½–22	16¼–26¾	Do.
	To wharves at Narragansett Pier	8	12	7½	12¼	Do.
	To anchorage in Wesqueag Cove	13	17	12½	17¼	Do.
	Dutch Island Harbor:					
	Through the South Channel to anchorage	16	20	15½	20¼	Do.
	Through the North Channel to anchorage	16	20	15½	20¼	Do.
	Wickford Harbor:					
	Through the Western Passage of the bay to Wickford Light-house	14	18¼	13½	18½	Do.
	To anchorage in Inner Harbor	8	12¼	7½	12½	Do.
	From the Northward around Quonset Point to Wickford Light-house	7	11¼	6½	11½	Do.
	To anchorage in Coddington Cove	18	22	17½	22¼	Do.
	Mount Hope Bay (R. I. and Mass.):					
	From abreast of Prudence Island Light-house to Fall River	17	21¾	16½	22	Do.
	To anchorage in Church's Cove	13	17¾	12½	18	Do.

Table of depths, Atlantic Coast—Continued.

MASSACHUSETTS, RHODE ISLAND, AND NEW YORK.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
NARRAGANSETT BAY (Harbors and Anchorages).	Mount Hope Bay—Continued.					
	To anchorage in Kickamuit River	8	12¾	7½	13	Coast Survey, 1868.
	To anchorage in Cole's River	13	17¾	12½	18	Do.
	To anchorage in Lee's River	8	12¾	7½	13	Do.
	Up Taunton River to Dighton	3¾	9	3¼	9½	U. S. Engineers, 1880.
	Up Taunton River to Weir	5½	9	5	9½	Do.
	Bristol Harbor:					
	Through Eastern Channel to anchorage	16	20½	15½	21	Coast Survey, 1868.
	Through Western Channel to anchorage	16	20½	15½	21	Do.
	To anchorage in Potowomut River	4	8½	3½	9	Do.
	Greenwich Bay:					
	To anchorage off Sally's Rock	13	17½	12½	18	Do.
	From abreast of Sally's Rock to anchorage off East Greenwich (Greenwich Cove)	10	14½	9½	15	Do.
	To anchorage in Apponaug River	3½	8	3	8½	Do.
	To anchorage in Old Warwick Cove	9	13½	8½	14	Do.
	To anchorage in Brush Neck Cove	1½	6	1	6½	Do.
	To anchorage in Potter's Cove	10	14½	9½	15	Do.
	Warren River:					
	From entrance to abreast of the town of Warren	11	15½	10½	16	Do.
	To anchorage below the Lower Middle Ground	12	16½	11½	17	Do.
	From Warren to the railroad bridge	8	12½	7½	13	Do.
	To anchorage in Smith's Cove	4	8½	3½	9	Do.
	From Warren to Barrington River Bridge	12	16½	11½	17	
	To anchorage in Barrington River	12	16½	11½	17	
	Providence River:					
	From abreast of Conimicut Light-house to anchorage off Providence	14	19	13½	20	Do.
	From Conimicut Light-house to Fox Point wharves	11	16	10½	17	Do.
	At head of harbor	6	11	5½	12	
	From abreast of Sassafras Point Light-house to East Providence Bridge	14	19	13½	20	Do.
	From abreast of Warwick Light house over the bar between Conimicut Point and Ohio Ledge.	17	22	16½	23	Do.
	To anchorage in Turtle Cove	5	10	4½	11	Do.
	From Main Channel of the river to anchorage in Pawtuxet Cove	1	6	½	7	Do.
	From East Providence Bridge to Upper Bridge—Seekonk River	27	32	26½	33	Do.
BLOCK ISLAND SOUND (Channels).	From off Point Judith to abreast of Watch Hill Light-house	33	36	32¾	37	Coast Survey, 1845.
	From off Point Judith to abreast of Little Gull Island Light-house	30	33	29¾	34	Do,
	From off Point Judith to abreast of Montauk Point	42	45	41¾	46	Do.
	From off southern end of Block Island to abreast of Little Gull Island	42	45	41¾	46	Do.
	From off southern end of Block Island to abreast of Gardiner's Point	42	45	41¾	46	Do.
	From off Montauk Point to abreast of Little Gull Island	30	33	29¾	34	Do.
BLOCK ISLAND SOUND (Anchorages).	To anchorage on Western side of Point Judith	19½	22½	19¼	23½	Do.
	To anchorage between Gardiner's Point and Eastern Plain Point (Gardiner's Island)	15	18	14¾	19	Do.
	To anchorage in Block Island Basin	7	10½	6½	11½	Atlantic Coast Pilot 1875.

Table of depths, Atlantic Coast—Continued.

CONNECTICUT AND NEW YORK.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
BLOCK ISLAND SOUND (Anchorages).	To anchorage in Fort Pond Bay	24	27	23¾	28	Coast Survey, 1845.
	To anchorage in southern part of Napeague Bay	24	27	23¾	28	Do.
	To anchorage in Napeague Harbor	8	11	7¾	12	Do.
	Through Ram Island Passage into Gardiner's Bay	12	15	11¾	16	Do.
	To anchorage in Tobacco-Lot Bay	7	10	6¾	11	Do.
FISHER'S ISLAND SOUND (Channels).	Through Watch Hill Passage into the Main Channel	27¼	30	27	30¼	Coast Survey, 1839.
	By Main Channel through the Sound	27	29¾	26¾	30	Coast Survey, 1877.
	Through Sugar Reef Passage into the Main Channel	23	25¾	22¾	26	Do.
	Through Catumb Passage into the Main Channel	30	32¾	29¾	33	Do.
	Through Lord's Passage into the Main Channel	21	23¾	20¾	24	Do.
	Through Wicopesset Passage into the Main Channel	16	18¾	15¾	19	Do.
	Through North Channel into Long Island Sound from Stonington	11	13¾	10¾	14	Do.
	Through the South Channel into Long Island Sound	19	21¾	18¾	22	Atlantic Coast Pilot, 1880.
FISHER'S ISLAND SOUND (Harbors and Anchorages).	Little Narragansett Bay:					
	To anchorage	7	9¾	6¾	10	Coast Survey, 1839.
	To anchorage off Sandy Point	8¼	11	8	11¼	Do.
	To anchorage in Pawcatuck River by North Channel through the Bay	3	5¾	2¾	6	Do.
	To anchorage in Pawcatuck River by South Channel through the Bay	4	6¾	3¾	7	Do.
	Stonington Harbor:					
	To anchorage	7	9¾	6¾	10	Coast Survey, 1874.
	To anchorage off Upper wharves	4¼	7	4	7¼	Do.
	To anchorage in East Harbor	10	12¾	9¾	13	Coast Survey, 1839.
	To anchorage in West Harbor	8	10¾	7¾	11	Do.
	To anchorage in Mystic River	12	14¾	11¾	15	Do.
	To Mystic Bridge	11¼	14	11	14¼	Do.
	To anchorage in Mumford's Cove	10	12¾	9¾	13	Do.
LONG ISLAND SOUND (Channels).	Through Main Channel from "The Race" to abreast of Cornfield Point Light-vessel	120	125¾	119½	126½	Do.
	Through Main Channel from Cornfield Point Light-vessel to abreast of Stratford Point Light-house	39½	45	39	45½	Do.
	Through Main Channel from Stratford Point Light-house to Throg's Neck	39½	45	39	45½	Do.
	Through North Channel from "The Race" to abreast of the southern end of Saybrook Bar	48	53¾	47½	54½	Do.
	Through North Channel from off Saybroook Bar to abreast of Stratford Point (junction with the Main Channel)	21½	27	21	27½	Do.
	Through "The Thimbles" Channel	27½	33	27	33½	Do.
	Through the South Channel from "The Race" to abreast of Cornfield Point Light-vessel	72½	78	72	78½	Do.
	Through the South Channel from Cornfield Point Light-vessel to abreast of Oyster Bay (junction with the Main Channel*	24½	30	24	30½	Do.
	Passage through Plum Gut into Gardiner's Bay	48½	51	48	51¼	Coast Survey, 1874.
LONG ISLAND SOUND (Harbors and Anchorages).	Thames River and New London Harbor:					
	Through Main Channel from Long Island Sound to anchorage off New London	25	27½	24¾	28	Coast Survey, 1839.
	At wharves of New London	11	13½	10¾	14	Do.
	At Groton wharves	9	11½	8¾	12	Do.

* This depth is found only off Eaton's Point. Elsewhere on this line there is not less than nine fathoms.

Table of depths, Atlantic Coast—Continued.

CONNECTICUT AND NEW YORK.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
LONG ISLAND SOUND (Harbors and Anchorages).	Thames River and New London Harbor—Cont'd.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
	Through Pine Island Channel from Fisher's Island Sound	21	23½	20¾	24	Coast Survey, 1839.
	From off Groton to abreast of Cow Point	24	26½	23¾	27	Do.
	From off Cow Point to abreast of Clarke's Cove by the East Channel	15	17½	14¾	18	Coast Survey, 1874.
	From off Cow Point to abreast of Clarke's Cove by the West Channel	13	15½	12¾	16	Do.
	From off Clarke's Cove to abreast of Trading Cove	10¼	13	10½	13½	Do.
	From off Trading Cove to Norwich	7	9½	6¾	10	Do.
	To the Upper Bridge—Shetucket River	7	9½	6¾	10	Do.
	At entrance to Trading Cove	1½	4	1¼	4½	Do.
	To anchorage in Trading Cove	5½	8	5¼	8½	Do.
	To anchorage in Paquatannock Cove	2	4½	1¾	5	Do.
	To anchorage in Horton's Cove	2½	5	2¼	5½	Do.
	To anchorage in Winthrop's Cove	10	12½	9¾	13	Coast Survey, 1838.
	To anchorage in Green's Harbor	7	9½	6¾	10	Do.
	Niantic Bay:					
	To anchorage	15	17½	14¾	18	Coast Survey, 1836.
	To mouth of Niantic River	10¼	12¾	10	13½	Do.
	Connecticut River:					
	Over Saybrook Bar	7	11	6½	11½	U. S. Engineers, 1880.
	After passing Bar to anchorage off Saybrook Point	18	22	17½	22½	Do.
	To anchorage in Westbrook Harbor	7	11	6½	11½	Coast Survey, 1878
	Duck Island Harbor:					
	To anchorage	13	17	12½	17½	Coast Survey, 1877
	Through Passage between Duck Island and Menunketesuck Point	20	24	19½	24½	Do.
	Through Passage between Duck Island and Kelsey's Point	15½	19½	15	20	Do.
	Through Passage between Stone Island Reef and East Ledge	19	23	18½	23½	Do.
	To Pier Head, Lewis' Landing	7	11	6½	11½	Do.
	To anchorage in Killingworth Harbor	8	12	7½	12½	Coast Survey, 1838
	To anchorage in Guilford Harbor	8	12	7½	12½	Do.
	Sachem's Head Harbor:					
	In the entrance	19	24½	18½	25	Do.
	To anchorage	19	24½	18½	25	Do.
	Passage north of Goose Rocks	13	18½	12½	19	Do.
	To Thimbles Anchorage	25½	30¾	25	31½	Do.
	Branford Harbor:					
	In the entrance	10	15½	9½	16	Do.
	To the landing	6	11½	5½	12	Do.
	To anchorage in Outer Harbor	13	18½	12½	19	Do.
	To anchorage in Inner Harbor	6	11½	5½	12	Do.
	New Haven Harbor:					
	Through Main Channel from Long Island Sound to Lower Bridge	13	19	12½	19½	Coast Survey, 1872
	Into Quinnipiac River and up to wharves	7	13	6½	13½	Do.
	Into Quinnipiac River and to Upper Bridge	1	7	½	7½	Do.
	Into Mill River through drawbridge to the Middle-Ground between the bridges	2	8	1½	8½	Do.
	Into Mill River and to Upper Bridge	1	7	½	7½	Do.
	To Oyster Point Wharves	1	7	½	7½	Do.
	To Oyster Point Bridge	2	8	1½	8½	Do.
	To anchorage in Morris' Cove	8	14	7½	14½	Do.

Table of depths, Atlantic Coast—Continued.

CONNECTICUT AND NEW YORK.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
LONG ISLAND SOUND (Harbors and Anchorages).	New Haven Harbor—Continued:	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
	To Forbes' Wharf	8	14	7½	14¼	Coast Survey, 1872.
	To anchorage in Milford Harbor	12	18	11½	18¼	Coast Survey, 1859.
	Housatonic River:					
	Over the bar	2	8	1½	8¼	Coast Survey, 1837.
	From inside the bar to Stratford	7	13	6½	13¼	Do.
	Bridgeport Harbor:					
	Over the bar to lower bridge	12	18½	11½	19½	U. S. Engineers, 1880
	To anchorage abreast of the city	12	18½	11½	19½	Do.
	Black Rock Harbor:					
	From entrance to the town	8½	15	8	16	Coast Survey, 1837.
	To anchorage in Outer harbor	12½	19	12	20	Do.
	To anchorage in Inner harbor	8½	15	8	16	Do.
	Over Southport Harbor bar to anchorage off wharves	4	11½	3¾	12	U. S. Engineers, 1880.
	Saugatuck River:					
	Over the bar	5	12½	4¾	13	Coast Survey, 1859.
	From inside bar to Clam Rock Point	9	16½	8¾	17	Do.
	To anchorage	9	16½	8¾	17	Do.
	Port Jefferson Harbor:					
	Approaching the entrance by the passage between Mount Misery Shoal and Mount Misery Point	16	23	15½	23½	Coast Survey, 1874.
	Over the bar	8	14½	7¾	15¼	U. S. Engineers, 1880.
	After passing the bar, to anchorage	18	24½	17¾	25¼	Coast Survey, 1874.
	Through passage into Conscience Bay	1	8	¾	8¼	Do.
	Through passage into Setauket Harbor	3	10	2¾	10¼	Do.
	Smithtown Bay:					
	To anchorage under Crane Neck Point	21½	29	21	30	Coast Survey, 1837.
	Into Stony Brook Harbor	3½	11	3	11¾	Do.
	To wharves in Stony Brook Harbor	4½	12	4	12¾	Do.
	In entrance to Nissequague River	1½	9	1	9¾	Do.
	To anchorage in Cockenoe's Island Harbor	8	15½	7¾	16	Coast Survey, 1859.
	Norwalk River:					
	Entrance from Cockenoe's Island Harbor to the northward of Betts' Island	5	12½	4¾	13	Coast Survey, 1839.
	Passage between Ram Island and Chimon's Island	3	10½	2¾	11	Do.
	Sheffield Island Harbor:					
	In the entrance	11	18½	10¾	19	Coast Survey, 1836.
	Up to anchorage	10	17½	9¾	18	Do.
	In entrance to Darien River	5½	13	5¼	13¼	Coast Survey, 1859.
	Huntington Bay:					
	To anchorage	19¾	27¼	19	28¼	Coast Survey, 1836
	To anchorage in Northport Bay	7¾	15¼	7	16¼	Do.
	To Northport Wharves	4¾	12¼	4	13¼	Do.
	Entrance to Duck Island Harbor	10¾	18¼	10	19¼	Do.
	To anchorage in Duck Island Harbor	6¾	14¼	6	15¼	Coast Survey, 1836.
	Entrance to Huntington Harbor	8¾	16¼	8	17¼	Do.
	To anchorage in Huntington Harbor	9¾	17¼	9	18¼	Do.
	Entrance to Lloyd's Harbor	11¾	19¼	11	20¼	Do.
	To anchorage in Lloyd's Harbor	8¾	16¼	8	17¼	Do.
	Oyster Bay:					
	To anchorage	20¼	27½	19	28¼	Do.
	To anchorage in Oyster Bay Harbor	9¼	16½	8	17¼	Do.
	To dock at Oyster Bay Village	6¼	13½	5	14¼	Do.
	Passage into Upper Harbor over the bar	13	22½	14	23¼	Do.
	To anchorage in Cold Spring Harbor	17¼	24½	16	25¼	Do.

Table of depths Atlantic Coast—Continued.

NEW YORK.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
LONG ISLAND SOUND (Harbors and Anchorages).	Stamford Harbor:					
	From entrance to mouth of Mill River	4	11⅛	3¾	12	Coast Survey, 1859.
	To anchorage in Roads	12	19⅛	11¾	20	Do.
	To anchorage in Inner Harbor	7	14⅛	6¾	15	Do.
	To anchorage in Greenwich Cove above Pelican Point	8	15⅛	7½	16	Do.
	To anchorage in Cos Cob Harbor	8	15⅛	7½	16	Do.
	To anchorage in Little Captain's Island Harbor	16	23⅛	15½	24	Atlantic Coast Pilot, 1880.
	Great Captain's Island Harbor:					
	To anchorage under western side of Calf Island	11	18⅛	10	19	Do.
	To anchorage between southern end of Calf Island and the southwestern end of Great Captain's Island	15	22⅛	14	23	Do.
	To anchorage in Bush's Harbor	7½	14⅛	7	15½	Coast Survey, 1837.
	At entrance to Byram River	2½	9⅛	2	10½	Do.
	Hempstead Harbor:					
	Channel to Harbor Beach	7	14¾	6⅛	15⅛	Coast Survey, 1859.
	To anchorage in Outer Harbor	13	20¾	13	21⅛	Do.
	Manhasset Bay:					
	Over bar at entrance	13⅛	20¾	13	22	Coast Survey, 1837.
	After passing bar, to anchorage off Mott's Point	14⅛	21¾	14	23	Do.
	To anchorage in Delancey's Cove	11⅛	19	11	19⅛	Do.
	To anchorage in New Rochelle Harbor	23⅛	31	23	31⅛	Do.
	To anchorage close under Hart Island (Hart and City Island Harbor)	21⅛	29	21	29⅛	Do.
	Pelham Bay:					
	To anchorage	7⅛	15½	7	16½	Do.
	Entrance to Hutchinson's River	7⅛	15½	7	16½	Do.
	To anchorage in Little Neck Bay	7⅛	14¾	7	16	Do.
EAST RIVER (Channels)	From Throg's Neck to Port Morris by the passage north of North Brother Island	48	53⅛	47⅛	54⅛	Coast Survey, 1841.
	From Throg's Neck to Port Morris by the passage between North and South Brother Islands.	24	29⅛	23⅛	30⅛	Do.
	From Throg's Neck to Port Morris, by the passage south of Riker's Island	22	27⅛	21⅛	28⅛	Coast Survey, 1841.
	By the Main Channel through Hell Gate	28	33⅛	27⅛	34⅛	Atlantic Coast Pilot, 1880.
	By the Middle Channel through Hell Gate	20	25⅛	19⅛	26⅛	Do.
	By the Eastern Channel through Hell Gate	33	38⅛	32⅛	39⅛	Do.
	Through the passage west of Blackwell's Island	30	35⅛	29⅛	36⅛	Coast Survey, 1841.
	Through the passage east of Blackwell's Island	24	29⅛	23⅛	30⅛	Do.
	From Blackwell's Island through to Hudson River	31	35⅛	30⅛	36	Coast Survey, 1855
	Through the Buttermilk Channel	28	32½	27⅛	33	Do.
EAST RIVER (Harbors and Anchorages).	To anchorage in Flushing Bay	7	12⅛	6⅛	13⅛	Coast Survey, 1841.
	Harlem River:					
	From Hell Gate to Mott Haven	17	22⅛	16⅛	23⅛	Coast Survey, 1856.
	Through the Passage between Ward's and Randall's Islands	11	16⅛	10⅛	17	Do.
	Passage to the bridge in Newtown Creek	17	22⅛	16⅛	23⅛	Do.
GARDINER'S BAY and Tributaries (Channels).	Through Main Entrance between Gardiner's Island and Plum Island	30½	32¾	30	33	Coast Survey, 1838
	Through the passage between Plum Island and Great Gull Island	21½	23¾	21	24	Do.
	Through Plum Gut	19½	21¾	19	22	Do.
	Passage through Shelter Island Sound, past Greenport, into Little Peconic Bay	19½	21¾	19	22	Coast Survey, 1839.

Table of depths, Atlantic Coast—Continued.

NEW YORK.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
GARDINER'S BAY and tributaries (Channels)—Cont'd.	Passage through Shelter Island Sound, past Sag Harbor, into Little Peconic Bay	*Feet.* 15¼	*Feet.* 17¾	*Feet.* 15	*Feet.* 18	Coast Survey, 1839.
	To anchorage in Orient Harbor	15¼	17¾	15	18	Do.
	Greenport Harbor:					
	To anchorage	21¼	23¾	21	24	Do.
	To Greenport wharves	7¼	9¾	7	10	Do.
	To anchorage in Pipes' Cove	18¼	20¾	18	21	Do.
	To anchorage in Southold Bay	15¼	17¾	15	18	Do.
	Sag Harbor:					
	To anchorage	13¼	15¾	13	16	Do.
	To Sag Harbor wharves	10¼	12¾	10	13	Do.
	To anchorage in Noyack Bay	21¼	23¾	21	24	Do.
	Little Peconic Bay:					
	Passage through the bay	19¼	21¾	19	22	Do.
	To anchorage on east side of Little Hog Neck	13¼	15¾	13	16	Do.
	To anchorage in Cutchogue Harbor	10¼	12¾	10	13	Do.
	Great Peconic Bay:					
	Channel through the bay	13¼	15¾	13	16	Do.
	To anchorage	16¼	18¾	16	19	Do.
	Channel to Jamesport	10¼	12¾	10	13	Do.
SOUTH COAST OF LONG ISLAND (Harbors and Anchorages).						
Fire Island Inlet*	Main Channel over Bar	12	13¾	11¾	14	Coast Survey, 1875.
	Channel to abreast of Light-house Wharf	11	12¾	10¾	13	Do.
Great South Bay	From abreast of Fire Island Light-house to the Fire Islands	8	9¾	7¾	10	Do.
	From Fire Islands to Smith's Wharf	3	4¾	2¾	5	Do.
	From Fire Islands to Nicoll's Point	6	7¾	5¾	8	Do.
	From Nicoll's Point to Howell's Point	7	8¾	6¾	9	Do.
	From Howell's Point to Bell's Dock	5	6¾	4¾	7	Do.
	From Bell's Dock to Smith's Point	2	3¾	1¾	4	Do.
	In the entrance to Connetquot River	3	4¾	2¾	5	Do.
	To anchorage in Nicoll's Bay, off mouth of Connetquot River	7	8¾	6¾	9	Do.
Gilgo Inlet*	In the entrance	11	12¾	10¾	13	Coast Survey, 1835.
New Inlet*	do	¾	2½	½	2¾	Do.
Rockaway Inlet*	do	13	17	12½	17¼	Coast Survey, 1877.
Jamaica Bay	Through Big Channel to abreast of Canarsie	6½	10½	6	10¾	Do.
	To Canarsie Landing	4¼	8	4	8¼	Do.
	Through Island Channel to Canarsie Landing	2½	6¼	2¼	6½	Do.
	Through Big Fishkill Channel to Duck Point Marshes	6¼	10	6	10¼	Do.
	Through Duck Point Channel	3¾	7½	3½	7¾	Do.
	Through Beach Channel to Broad Channel	18	22	17½	22¼	Do.
	At Rockaway Wharves	7	11	6½	11¼	Do.
	Passage over Long Bar	9½	13½	9	13¾	Do.
	From Long Bar to Sloop Bar	6½	10½	6	10¾	Do.
	Through Grass Hassock Channel to Norton's Point	3	7	2½	7¼	Do.
	Through Broad Channel to Hell-Gate	7	11	6½	11¼	Do.
	Through Hell-Gate to Nigger Point	6½	10½	6	10¾	Do.
	Through Hassock Creek to Green Point	3½	7½	3	7¾	Do.
	Through "The Raunt" to Goose Hill Channel	4	8	3½	8¼	Do.
	Through the Pumpkin Patch Channel	5½	9½	5	9¾	Do.
Dead Horse Inlet*	Over the Bar	4½	8¼	4¼	8½	Do.
	Through Deep Creek and Irish Channel to Island Channel (Jamaica Bay)	3¼	7	3	7¼	Do.

* Shifting sand bars.

Table of depths, Atlantic Coast—Continued.

NEW YORK AND NEW JERSEY.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
NEW YORK BAY AND HARBOR (Channels).	Through Gedney's Channel	23	27¾	22½	28	Coast Survey, 1856.
	Through Main Channel, after passing Bar	31	35¾	30½	36	Coast Survey, 1869.
	Through Swash Channel, after passing Bar	24	28¾	23½	29	Coast Survey, 1866.
	Through South Channel	22	26¾	21½	27	Coast Survey, 1856.
	Through East Channel	20	24¾	19½	25	Do.
	Through Fourteen-Feet Channel	14½	19¼	14	19½	Do.
	Through False Hook Channel	21	25¾	20½	26	Do.
	Channel north of East Bank	14	18¾	13½	19	Do.
	Through the Lower Bay to The Narrows	22½	27¼	22	27½	Do.
	Through The Narrows to abreast of the Quarantine Station	36	40¾	35½	41	Do.
	From Quarantine through Upper Bay to anchorage in Hudson River off New York City	30	34¾	29½	35	Do.
	Through Buttermilk Channel into East River	28	32¾	27½	33	Coast Survey, 1855.
	Passage north of Governor's Island into East River	31	35¾	30½	36	Do.
Tributaries to New York Bay						
(Sandy Hook Bay)	To anchorage	18	22¾	17½	23	Coast Survey, 1856.
(Raritan Bay)	To anchorage in Horse-Shoe Cove	8	12¾	7½	13	Do.
	From Sandy Hook to Seguine Point	14½	19¼	13¾	19½	Do.
	From Seguine Point to Ward's Point	19	23¾	18¾	24	Coast Survey, 1857.
	Channel across the flats to mouth of Raritan River	11	15¾	10¾	16	Do.
	To Railroad Bridge, Raritan River.	11	15¾	10¾	16	Do.
	Raritan River from South Amboy to Sayreville	6½	11½	6	12	Coast Survey, 1872.
	From Sayreville to New Brunswick	6½	11½	6	12	Do.
	To anchorage in Princess Bay	16	20¾	15½	21	Coast Survey, 1857.
	To anchorage off Keyport	4	9½	3½	10	Coast Survey, 1841.
	Entrance to Shrewsbury River	3½	8½	3	9	Coast Survey, 1840.
	Entrance to Navesink River	3½	8½	3	9	Do.
	To anchorage off Port Monmouth	10	14¾	9½	15½	Do.
(Arthur Kill)	From Ward's Point to Tuft's Point	15	17¼	14¾	17¾	Coast Survey, 1855.
	From Tuft's Point to Prall's Island	14	16¼	13¾	16¾	Do.
	Through Northwest Reach to Elizabethport	13	15¼	12¾	15¾	Do.
	Channel east of Prall's Island	11	13¼	10¾	13¾	Do.
(Gravesend Bay)	To anchorage	9	13¼	8½	13¾	Do.
(Kill Van Kull)	Through to Bergen Point, Newark Bay	25	27¼	24¾	27¾	Do.
(Newark Bay)	Channel along north shore of Staten Island from Bergen Point to Elizabethport	9	11¼	8¾	11¾	Do.
	Channel from Bergen Point to Hackensack River Bridge	6½	11¼	6	11½	Coast Survey, 1872.
	Channel from Bergen Point to Passaic River Bridge	2½	7¼	2	7½	Do.
	To anchorage in Bay just above Jersey Central Railroad Bridge	15	19¾	14½	20	Do.
(Gowanus Bay)	To anchorage	12	16¼	11½	17	Do.
(Hudson River)	From New York to Yonkers	28	32¼	27½	33	Coast Survey, 1854.
	From Yonkers to abreast of Piermont	30	33½	29½	34	Do.
	To abreast of Tarrytown	31	34½	30½	35	Do.
	From Tarrytown to abreast of Sing Sing	24	27½	23¼	27¾	Do.
	From Sing Sing to abreast of Haverstraw	30	33½	29¾	33¾	Do.
	To abreast of Peekskill	28	31	27¾	31½	Do.
	From Peekskill to West Point Light-house	60	62¾	59¾	63	Coast Survey, 1857.
	From West Point to Newburgh	36	38¾	35¾	39	Do.
	From Newburgh to Poughkeepsie	39	42¼	38¾	42½	Coast Survey, 1859.
	From Poughkeepsie to abreast of Rondout	31	34¾	30¾	35½	Do.
	From Rondout to abreast of Glasco	21	24¾	20¾	25½	Coast Survey, 1862
	From abreast of Glasco to Saugerties	23	27	22½	27½	Do.
	From Saugerties to Catskill (Main Channel)	21	25	20½	25½	Do.

Table of depths, Atlantic Coast—Continued.

NEW YORK AND VERMONT.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Tributaries to New York Bay: (Hudson River).	From Catskill to Hudson City	28	32	27½	32½	Coast Survey, 1862.
	From Hudson City to New Baltimore	11	14¾	10¼	15¼	Coast Survey, 1863.
	From New Baltimore to Albany	9½	12½	9¾	12½	U. S. Engineers, 1880.
	From Albany to Troy	8	10¾	7¾	11	Do.
	To anchorage in Haverstraw Bay	8	11½	7¾	11¾	Coast Survey, 1854.
	To anchorage off Garrison's Landing	25	27¾	24¾	28	Coast Survey, 1857.
	To anchorage in Vanderberg's Cove	3	6¼	2¾	6½	Coast Survey, 1860.
	Up Rondout Creek to Rondout	13	16¾	12¾	17½	U. S. Engineers, 1880.
	Through The Maelstrom	19	23	18½	23½	Coast Survey, 1862.
	Channel into Hallenbeck's Creek	9	13	8½	13½	Do.
LAKE CHAMPLAIN (Channels).	From Fort Montgomery to Isle La Motte Light-house	11½	No Tides.			Coast Survey, 1870–'74.
	Through Point au Fer Channel	8	......	......	......	Do.
	Through Passage between Point au Fer Reef and Isle La Motte	15	......	......	......	Do.
	Passage between Long Point Shoal and Gull Island Reef	22	......	......	......	Do.
	Passage between Butler's Island and Gull Island Reef	23	......	......	......	Do.
	Passage between Butler's Island and Knight's Island	21	......	......	......	Do.
	Passage between Wood's Island and the mainland	12½	......	......	......	Do.
	Passage west of Valcour's Island	17	......	......	......	Do.
	Passage between Providence Island and Grand Isle	7	......	......	......	Do.
	Passage between Allen's Point and Hog's Back Island	7	......	......	......	Do.
	Through passage between Chimney Point and Crown Point	25	......	......	......	Do.
	From Crown Point through Whitehall Narrows to Whitehall	8	......	......	......	Do.
LAKE CHAMPLAIN (Harbors and Anchorages).	Missisquoi Bay:					
	From abreast of Province Point to Stevenson Point	10	......	......	......	Do.
	To anchorage in Chapman's Bay	7½	......	......	......	Do.
	To anchorage in Ransom's Bay	9	......	......	......	Do.
	Alburgh Passage:					
	From Stony Point to Horse-Shoe Shoal	10½	......	......	......	Do.
	To anchorage in Dillenbeck's Bay	7	......	......	......	Do.
	To anchorage in Squires Bay	7	......	......	......	Do.
	To anchorage in Macomb's Bay	6	......	......	......	Do.
	To anchorage in Pelot's Bay	13½	......	......	......	Do.
	Through La Motte Passage	11	......	......	......	Do.
	To anchorage in King's Bay	8	......	......	......	Do.
	To anchorage in Little Monti Bay	11	......	......	......	Do.
	To anchorage in Monti Bay	13	......	......	......	Do.
	To anchorage under north shore of Treadwell's Bay	14	......	......	......	Do.
	The Gut:					
	In the Eastern Entrance	9	......	......	......	Do.
	In the Western Entrance	6½	......	......	......	Do.
	Through the Passage	7	......	......	......	Do.
	To anchorage in Hibbard's Bay	6½	......	......	......	Do.
	To anchorage in McQuam Bay	6	......	......	......	Do.
	To anchorage in City Bay	8	......	......	......	Do.
	To anchorage in Lapan's Bay	11	......	......	......	Do.

Table of depths, Atlantic Coast—Continued.

NEW YORK AND VERMONT.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
LAKE CHAMPLAIN (Harbors and Anchorages)—Continued.	Saint Alban's Bay:		No tides.			
	In the Entrance	21				Coast Survey, 1870-'74.
	At Saint Alban's Bay Wharf	6				Do.
	To anchorage on west side of Bay	10				Do.
	Keeler's Bay:					
	To anchorage under south shore	15				Do.
	To anchorage under west shore	9½				Do.
	Cumberland Bay:					
	At Plattsburgh wharves	8				Do.
	To anchorage in Bay, close along west side of Cumberland Head	10				Do.
	To Anchorage behind Breakwater	14				Do.
	Mallett's Bay:					
	In the Entrance	63				Do.
	To anchorage under Pickerel Point	24				Do.
	At the wharves in Port Kent	15				Do.
	At the wharves in Port Jackson	9				Do.
	Corlear's Bay:					
	To Port Douglass	11				Do.
	To anchorage near wharf	27				Do.
	Burlington Harbor:					
	At Burlington wharves	13				Do.
	To anchorage behind Breakwater	21				Do.
	Shelburne Bay:					
	Entrance east of Proctor's Shoal	26				Do.
	Entrance west of Proctor's Shoal	21				Do.
	To anchorage off Ship-Yard	14				Do.
	To anchorage in Willsborough Bay off Frisbie's Point	32				Do.
	To anchorage in Meach's Cove	15				Do.
	To the wharves in Essex Harbor	10				Do.
	To anchorage in Whalon's Bay	31				Do.
	To anchorage in McNeil's Bay	13				Do.
	To anchorage in Kingsland Bay	22				Do.
	To anchorage in Porter's Bay	16				Do.
	To anchorage in Field's Bay	3				Do.
	To anchorage in Rock Harbor	63				Do.
	To anchorage in Barn Rock Harbor	64				Do.
	To anchorage in Basin Harbor	6				Do.
	Northwest Bay:					
	To anchorage under north shore	21				Do.
	At Westport wharves	8				Do.
	To anchorage in Button Bay	8				Do.
	To anchorage in Arnold's Bay	8				Do.
	To anchorage in Cole's Bay	11				Do.
	To the Wharves in Port Henry	5½				Do.
	To anchorage in Bulwagga Bay	13				Do.
	At Wharves at Crown Point Landing	6½				Do.
	At Wharf at Larrabee Landing	7				Do.
	At Wharf at Ticonderoga Landing	7				Do.
	At Wharf at Orwell Landing	11½				Do.
	At Wharf at Benson's Landing	12				Do.
	At Wharf at Cold Spring	16				Do.
	Passage to Wharf at Chubb's Dock	6½				Do.
	To Wharf at Snowdy's Dock	22				Do.
	At the wharves in Whitehall	27				Do.
	In the Entrance to South Bay	5½				Do.

Table of depths, Atlantic Coast—Continued.

NEW JERSEY AND DELAWARE.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	Low water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Barnegat Inlet	Over the Bar*	7	9	6¾	9¼	Coast Survey, 1876.
	From inside the Bar, through Oyster Creek Channel, to Barnegat Bay	8	10	7¾	10¼	Do.
Barnegat Bay	From Oyster Creek Channel up the Bay to abreast of Tom's River entrance	4	5½	3¾	5¾	Do.
	Up Tom's River to town	5	6	4¾	6¼	Do.
	From abreast of Tom's River to entrance to Metedeconk River	4	4¾	3¾	5	Do.
	Through passage into Metedeconk River	5½	6	5¼	6¼	Do.
	From Oyster Creek Channel, through southern part of the bay, into Little Egg Harbor	4	5	3¾	5¼	Do.
	Channel to Seaside Park Wharf	4½	5½	4¼	5¾	Do.
	To anchorage in Goose Creek	3	3¾	2¾	4	Do.
	To anchorage in Applegate's Cove	3	3¾	2¾	4	Do.
	To anchorage in Mosquito Cove	3	3¾	2¾	4	Do.
	To anchorage in Kettle Creek	3	3¾	2¾	4	Do.
	To anchorage in Cedar Creek	5	5¾	4¾	6	Do.
	To anchorage in Forked River	5	5¾	4¾	6	Do.
New Inlet*	Entrance through Tucker's Cove Inlet to abreast of Anchoring Islands	7	10½	6½	10¾	Atlantic Coast Pilot, 1882.
	Entrance through Little Egg Harbor Inlet to abreast of Anchoring Islands	7	10½	6½	10¾	Do.
Little Egg Harbor	From abreast of Anchoring Islands, through Main Channel, to Long Point	8	11½	7½	11¾	Coast Survey, 1873.
	From Long Point to Jessie's Point	4	7½	3½	7¾	Do.
	Through Sheepshead Creek into Great Bay	2	4¾	1¾	5	Do.
	Through Beach Channel into Barnegat Bay	4	6¾	3¾	7	Do.
Great Bay	Passage through Shooting Thoroughfare into the Bay	6½	9¾	6	10	Coast Survey, 1871.
	Across the flats to Mullicas River	4	7½	3½	7¾	Do.
	In the entrance to Mullicas River	6½	10	6	10¼	Do.
	Up Mullicas River to abreast of Bass River entrance	11	14½	10½	14¾	Do.
Brigantine Inlet*	Over the Bar	4	7½	3½	7¾	Atlantic Coast Pilot, 1882.
	Through Brigantine Channel to Grassy Bay	5½	9	5	9¼	Coast Survey, 1872.
	To anchorage in Brigantine Channel just inside the Bar	15	18½	14½	18¾	Do.
Absecon Inlet*	Over the Bar	7	11	6¾	11¼	Atlantic Coast Pilot, 1882.
	Abreast of Absecon Light-house	20	24	19¾	24¼	Do.
	At Atlantic City Wharf	18	22	17¾	22¼	Do.
Great Egg Harbor Inlet*	Over the Bar	7	10½	6¾	10¾	Do.
Corson's Inlet*	do	7	10½	6¾	10¾	Do.
Townsend's Inlet*	do	4	7½	3¾	7¾	Do.
Hereford Inlet*	do	6½	10	6¼	10¼	Do.
Cold Spring Inlet*	do	4	8½	3¾	8¾	Do.
DELAWARE BAY AND RIVER (Channels).	From Five Fathom Bank Light-ship to abreast of Cape Henlopen	38	42½	37½	43¼	Coast Survey, 1841–'47.
	Entering on Delaware Breakwater Range to abreast of Cape Henlopen	36	40½	35½	41¼	Do.
	To anchorage behind Delaware Breakwater	19½	24	19	24¾	Coast Survey, 1863.
	From Cape Henlopen, through Main Channel, to abreast of Ship John Shoal Light-house	27	31	26½	31¾	Atl. Coast Pilot, 1882.

* Shifting sand-bars.

Table of depths, Atlantic Coast—Continued.

NEW JERSEY, DELAWARE, PENNSYLVANIA AND VIRGINIA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
DELAWARE BAY AND RIVER (Channels)—Cont'd.	Through Cape May Channel	20	24½	19¼	25¼	Coast Survey, 1841–'47.
	Entering by the Through Channel	20	24½	19¼	25¼	Do.
	Through Ricord's Channel	15	19½	14¼	20¼	Coast Survey, 1841–'43.
	Through Blunt's Channel	14	18½	13¼	19¼	Do.
	Through Blake's Channel	15	19	14¼	19¾	Atl. Coast Pilot, 1882.
	Through the Delaware Shore Channel	8	12	7¼	12¾	Do.
	Entering by the Hen and Chickens Channel	16	20½	15¼	21¼	Do.
	From Ricord's Channel, across the flats, to Fourteen Feet Bank Light-vessel	15¾	19½	15	20¼	Do.
	From Blunt's Channel to Cross Ledge Lighthouse	12¾	16½	12	17¼	Do.
	Through Passage just north of Cross Ledge	14	18	13¼	18¾	Do.
	From abreast of Ship John Shoal Light-house, through Main Channel (on the Ranges), to Philadelphia	20	26	19¾	26¾	Coast Survey, 1881.
Tributaries to Delaware Bay and River.	Through Delaware City Channel	19½	25½	19	25¾	Coast Survey, 1875.
	To the Wharf at Lewes	8	12½	7½	13¼	Coast Survey, 1841–'43.
(Maurice River)	Entrance to River	5	11½	4½	11¾	Atl. Coast Pilot, 1882.
	Channel to Port Norris	15	21½	14½	21¾	Do.
	Channel to Mauricetown	15	21½	14½	21¾	Do.
(Mahon's River)	Over Bar at entrance	5	11½	4½	11¾	Do.
	Channel to abreast of Light-house	6	12½	5½	12¾	Do.
(Dona River)	In the entrance	5	11½	4½	11¾	Do.
	Channel to Dona Landing	12	18	11½	18½	Do.
(Cohansey Creek)	Over Bar at entrance	7½	13½	7	14	Do.
	Channel to Greenwich Wharf	13½	19½	13	20	Do.
(Duck Creek)	Entrance to Creek	6½	12½	6	13	Coast Survey, 1843.
	Channel to Short's Landing	6½	12½	6	13	Do.
(Salem Creek)	Entrance over the Bar	7	13	6½	13½	Atl. Coast Pilot, 1882.
	Channel to Salem	10	16	9½	16½	Do.
(Christiana Creek)	From Entrance to Brandywine Creek	13	19	12½	19½	Do.
	Channel to Wilmington	12	18	11½	18½	Do.
	Channel to Railroad Bridge (Brandywine Creek)	5½	11½	5	11¾	Coast Survey, 1841.
(Schuylkill River)	To Penrose Ferry Bridge	20	25¾	19¾	26½	U. S. Engineers, 1882.
	To Gray's Ferry Bridge	16	21¾	15¾	22½	Do.
	To Market Street Bridge	13	18¾	12¾	19½	Coast Survey, 1871.
	To Fairmount Bridge	11	16¾	10¾	17½	Do.
COAST FROM CAPE HENLOPEN TO CAPE CHARLES.						
Indian River Inlet*	Over Bar at Entrance	2½	7½	2	7¾	Atl. Coast Pilot, 1882.
	To mouth of Indian River	3½	8½	3	8¾	Coast Survey, 1847.
	To Reboboth Bay	2½	7½	2	7¾	Do.
Chincoteague Anchorage	To anchorage under the Shoals, off mouth of the Inlet	19	21¾	18¾	22	Coast Survey, 1851.
Chincoteague Inlet*	Over the Bar	8	10¾	7¾	11	Do.
	To anchorage inside the Bar	18	20¾	17¾	21	Do.
Assawoman Inlet*	Over the Bar	4	6¾	3¾	7	Do.
Gargathy Inlet*	do	4	6¾	3¾	7	Do.
Matomkin Inlet*	do	7	10½	6¾	11½	Coast Survey, 1863.
	Through Folly Creek to Landing	6	9½	5¾	10½	Do.
	Through Matomkin Bay to mouth of Parker's Creek	5	8½	4¾	9½	Do.
	To anchorage inside the Bar	20	23½	19¾	24½	Do.

* Shifting sand-bars.

Table of depths, Atlantic Coast—Continued.

VIRGINIA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
COAST FROM CAPE HENLOPEN TO CAPE CHARLES.		Feet.	Feet.	Feet.	Feet.	
(**Wachapreague** Inlet*)	Over Bar through East Channel	8	12½	7½	13	Coast Survey, 1852.
	Over Bar through North Channel	9	13½	8½	14	Do.
	To anchorage inside the Bar	21	25½	20½	26	Coast Survey, 1871.
	Passage through Black Rock Reach	12	16½	11½	17	Do.
	Through Finney's Creek to Landing	4	8½	3½	9	Do.
	Passage through Horse Shoe Lead	26	30½	25½	31	Do.
	Through Millstone Channel	12	16½	11½	17	Do.
	Through Bradford's Channel	9	13½	8½	14	Do.
(**Little Machipongo** Inlet*)	Over Bar through North Channel	12	16½	11½	17½	Coast Survey, 1871.
	Over Bar through East Channel	7	11½	6½	12½	Do.
	To anchorage in Sandy Island Channel	26	30½	25½	31½	Do.
	Through Sandy Island Channel to Lower Gap	25	29½	24½	30½	Do.
	To anchorage in North Inlet	26	30½	25½	31½	Do.
	Through North Inlet into Great Machipongo River	6	10½	5½	11½	Do.
(**Great Machipongo** Inlet*)	Over Bar through East Channel	11	15½	10½	16½	Coast Survey, 1853.
	Over Bar through Beach Channel	12	16½	11½	17½	Do.
	Over Bar through South Channel	7	11½	6½	12½	Do.
	Through Great Machipongo River to abreast of Castle Ridge Creek	23	27½	22½	28½	Coast Survey, 1871.
	Through Great Machipongo River to Bell's Neck	17	21½	16½	22½	Do.
	Through "The Deeps" to Point Creek	21	25½	20½	26½	Do.
	To anchorage inside the Bar	20	24½	19½	25½	Do.
(**Sand Shoal Inlet***)	Over the Bar	13	17¼	12½	17¾	Coast Survey, 1853.
	Through Sand Shoal Channel to The Thoroughfare	30	34¼	29½	34¾	Coast Survey, 1870.
	Through The Thoroughfare to Magothy Bay	16	20¼	15½	20¾	Do.
	Through "Sergeant's Turn" to Indiantown Creek	24	27¾	23½	28¼	Do.
	Through Eckichy Channel to "The Forks"	27	30¾	26½	31½	Do.
	To anchorage in Lone Channel, abreast of Cobb's Landing	19	22¾	18½	23½	Do.
(**Ship Shoal Inlet***)	Over the Bar	8	11½	7¾	12¼	Atl. Coast Pilot, 1882.
	At anchorage inside the Bar	24	27½	23¾	28¼	Do.
	Through Ship Shoal Channel into Smith's Island Bay	15	18½	14¾	19¼	Coast Survey, 1870.
(**Smith's Island Inlet** and Bay*)	Over the Bar	7	9¾	6¾	10	Coast Survey, 1852.
	At anchorage on west side of Smith's Island	19	21¾	18¾	22	Coast Survey, 1869.
	Through Magothy Bay to "The Thoroughfare" (Sand Shoal Channel)	14	16¾	13¾	17	Do.
	Through Magothy Bay to Ship Shoal Channel	2	4¾	1¾	5	Do.
CHESAPEAKE BAY (Channels).	From entrance through Main Ship Channel to Hampton Roads	30	32½	29¾	33	Coast Survey, 1852–'73.
	From entrance through Main Ship Channel to abreast of Wolf Trap Light-house	30	32½	29¾	33	Do.
	Through North Channel around Cape Charles to abreast of Wolf Trap Light-house	21	23½	20¾	24	Do.
	Through Middle-Ground Channel to abreast of Wolf Trap Light-house	19	21¼	18¾	22	Do.
	Through Main Ship Channel up the Bay from Wolf Trap Light-house to abreast of Smith's Point Light-house	26	27½	25¾	28	Coast Survey, 1854.

* Shifting sand-bars.

Table of depths, Atlantic Coast—Continued.

MARYLAND AND VIRGINIA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
CHESAPEAKE BAY (Channels).	From Smith's Point Light-house to abreast of Point Lookout Light-house	43	44½	42¾	45	Coast Survey, 1849.
	From Point Lookout to abreast of Cove Point Light-house	39	40½	38¾	41	Do.
	From Cove Point to abreast of Sharp's Island Light-house	37	38½	36¾	39	Coast Survey, 1848.
	From Sharp's Island to abreast of Poplar Island	34	35	33¾	35¼	Coast Survey, 1847.
	From Poplar Island to abreast of Swan Point	25	26	24¾	26¼	Coast Survey, 1846.
	From Swan Point to abreast of Mitchell's Bluff	19	20	18¾	20¼	Coast Survey, 1845.
	From Mitchell's Bluff to abreast of Bush River Entrance	16	17	16¾	17¼	Do.
CHESAPEAKE BAY (Anchorages).	From Bush River to abreast of Rich Neck	15	16	14¾	16¼	Coast Survey, 1846.
	From Rich Neck to abreast of Turkey Point Light-house	15	16	14¾	16¼	Do.
	Lynn Haven Roads:					
	To anchorage	21	23½	20¾	24	Coast Survey, 1854.
	In the Entrance to Lynn Haven Inlet	9	11½	8¾	12	Do.
	Willoughby's Bay:					
	In the Entrance around Fort Wool	7	9½	6¾	10	Coast Survey, 1873.
	To anchorage under the Sand Spit	7	9½	6¾	10	Do.
	Hampton Roads:					
	To anchorage off Elizabeth River Entrance	23	25½	22¾	26	Do.
	To anchorage behind Hampton Bar	7	9½	6¾	10	Do.
Tributaries to Chesapeake Bay.						
(Elizabeth River)	To abreast of the City of Norfolk	21	23½	20½	24	Do.
	To the Navy-yard	21	23½	20½	24	Do.
	Through Southern Branch to Dismal Swamp Canal	10	12½	9½	13	Do.
	Through Southern Branch from Railroad Bridge to Chesapeake and Albemarle Canal	7	9½	6½	10	Do.
	Up the Eastern Branch to Broad Creek	11	13½	10½	14	Do.
	Up the Western Branch to Drum Point Creek	8	10½	7½	11	Do.
	In the Entrance to Tanner's Creek	6	8½	5½	9	Do.
	To Tanner's Creek Bridge	7	9½	6½	10	Do.
(Nansemond River)	Across flats at the Entrance	16	18½	15½	19	Coast Survey, 1872.
	From Pig Point to Western Branch	10	12½	9½	13	Do.
	From Western Branch to Suffolk wharves	5	7½	4½	8	Do.
(James River)	To abreast of Newport News through Channel north of Middle Ground	21	23½	20½	24	Coast Survey, 1874.
	To abreast of Newport News through Channel south of Middle Ground	25	27½	24½	28	Do.
	From Newport News to White Shoal Light-house	21	23½	20½	24	Coast Survey, 1873.
	From White Shoal Light-house to Point of Shoals Light-house	18	20½	17½	21	Do.
	From Point of Shoals Light-house to Deep Water Shoals Light-house	22	24½	21½	25	Do.
	From Deep Water Shoals Light-house to Dancing Point	16	18	15½	18½	Coast Survey, 1874.
	From Dancing Point to Harrison's Bar	15	17½	14½	17¾	Coast Survey, 1875.
	Across Harrison's Bar	14	10½	13½	16¾	Do.
	From Harrison's Bar to City Point	18½	21½	18	21½	Do.
	From City Point to Dutch Gap Canal	15	18	14½	18½	Coast Survey, 1879.
	Through Dutch Gap Canal	14	17	13½	17½	Coast Survey, 1880.
	Through Trent's Reach	7½	10½	7	10½	Do.
	From Dutch Gap Canal to Graveyard Reach	19	22	18½	22½	Do.

Table of depths, Atlantic Coast—Continued.

VIRGINIA AND MARYLAND.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Tributaries to Chesapeake Bay:						
(James River—Continued)	Through Graveyard Reach	13	16	12½	16½	Coast Survey, 1880.
	From Graveyard Reach to Rockett's	13	16	12½	16½	U. S. Engineers, 1880.
	In the entrance to Appomattox River	15½	18¼	15¼	18½	Coast Survey, 1880.
	Up Appomattox River to Port Walthall	14	16¾	13¾	17	Coast Survey, 1852.
	Entering Chickahominy River by channel along north shore under Barret's Point	14	16	13½	16½	Coast Survey, 1874.
	Across the main bar at entrance to Chickahominy River	7	9	6½	9½	Do.
	Up Chickahominy River from Barret's Point to Yarmouth Creek	15	17	14½	17½	Do.
	Pagan Creek, from entrance to Smithfield wharves	7	9½	6½	10	Coast Survey, 1872.
	Warwick River, from entrance to Potash Creek	4	6½	3½	7	Do.
	To anchorage off Newport News	40	42½	39½	43	Coast Survey, 1874.
(Back River)	Over the Outer Bar	11	13½	10¾	14	Coast Survey, 1868.
	Over the Inner Bar	7	9½	6¾	10	Do.
	To Booker's Point	6½	9	6¼	9½	Do
Poquosin River	From entrance to Lamb's Creek	7	9½	6¾	10	Do.
	To anchorage off York Point	15	17½	14¾	18	Do.
(York River)	From entrance to Yorktown	34	36½	33¾	37	Coast Survey, 1857.
	From Yorktown to Terrapin Point	19	21½	18¾	22	Do.
	From Terrapin Point to West Point	13	15½	12¾	16	Do.
	To anchorage just above Too's Point Light-House	30	32½	29¾	33	Do.
(Mobjack Bay)	From entrance to mouth of North River	18	19¼	17¾	20	Coast Survey, 1854, '68
	To anchorage off mouth of Severn River	18	19¼	17¾	20	Coast Survey, 1868.
	To anchorage off mouth of East River	16	17¼	15¾	18	Do.
	Up Severn River from entrance to Eastern and Western Branches	19	20¼	18¾	21	Do.
	To Wilson's Creek (Ware River)	16	17¼	15¾	18	Do.
	Up North River, five miles above entrance	8	9¼	7¾	10	Do.
	Over the bar at mouth of East River	14	15¼	13¾	16	Do.
	To Pull-in Creek, East River	14	15¼	13¾	16	Do.
(Cherrystone Inlet)	From entrance to Cherrystone Light-House	12	13¼	11¾	14	Coast Survey, 1873.
	To Cherrystone Wharf	9	10¼	8¾	11	Do.
(Hunger's Creek)	From entrance to "The Divide"	6½	7¾	6¼	8½	Coast Survey, 1868.
(Naswaddox Creek)	From entrance to Warehouse Creek	4	5¼	3¾	6	Do.
(Piankatank River)	From entrance to Wilton Point	19	20¼	18¾	21	Coast Survey, 1869.
	From Wilton Point to Ferry Point	15	16¼	14¾	17	Do.
	From Ferry Point to Deep Point	6½	7¾	6¼	8½	Do.
	To anchorage in Hill's Bay	19	20¼	18¾	21	Do.
	To anchorage in Godfrey's Bay	19	20¼	18¾	21	Do.
	To anchorage in Fishing Bay	19	20¼	18¾	21	Do.
	In the entrance to Milford Haven	3¼	4½	3	5¼	Do.
	At anchorage in Milford Haven	8	9¼	7¾	10	Do.
(Occohannock Creek)	To Heath's Landing	9	10¼	8¾	11	Coast Survey, 1868.
	To abreast of Sandy Point	6½	7¾	6¼	8½	Do.
(Rappahannock River)	From entrance to Tappahannock	11½	13	11¼	13½	Coast Survey, 1853–'57
	From Tappahannock to Occupacia Creek	7½	8¾	7¼	9½	Do.
	From Occupacia Creek to Saunders' Wharf	17	18½	16¾	19	Do.
	From Saunders' Wharf to Long Point	14	15½	13¾	16	Do.
	From Long Point to Port Royal	7½	9	7¼	9½	Do.
	From Port Royal to Spring Hill	6	7½	5¾	8	Do.
	From Spring Hill to Mansfield	4	5½	3¾	6	Do.

Table of depths, Atlantic Coast—Continued.

VIRGINIA AND MARYLAND.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
Tributaries to Chesapeake Bay:		*Feet.*	*Feet.*	*Feet.*	*Feet.*	
(Rappahannock River—Cont'd.)	From Mansfield to Fredericksburg	3	4½	2¾	5	Coast Survey, 1853–'57.
	Corrotoman River, from entrance to abreast of the Eastern Branch	16	17¼	15¾	18	Coast Survey, 1869.
(Little Bay)	To anchorage off North Point	18	19¼	17¾	20	Do.
	In the entrance to Antepoison Creek	7	8¼	6¾	9	Do.
(Dimer's Creek)	In the entrance	13	14¼	12¾	15	Do.
	To the landing	9	10¼	8¾	11	Do.
(Indian Creek)	From entrance two miles up	16	17¼	15¾	18	Do.
(Dividing Creek)	From entrance to "The Divide"	15	16¼	14¾	17	Do.
(Nandua Creek)	From entrance to Carratuck Creek	7	8½	6¾	9	Coast Survey, 1868.
(Pungoteague Creek)	To abreast of the wharves	14	15¼	13¾	16	Coast Survey, 1851, '68.
(Onancock Creek)	To the village of Onancock	4½	5¼	4	6	Coast Survey, 1869.
(Chesconessex Creek)	To abreast of Tobacco Island	7	8½	6¾	9	Do.
(Great Wicomico River)	From entrance to Barrett's Creek	19	20½	18¾	21	Do.
	To anchorage in Ingram's Bay	15	16½	14¾	17	Do.
	In the entrance to Mill Creek	13	14½	12¾	15	Do.
	In the entrance to Cockle's Creek	14	15½	13¾	16	Do.
(Potomac River)	From Point Lookout to Wicomico River	23	24⅛	22¾	25	Coast Survey, 1860–'62.
	From Wicomico River to Lower Cedar Point	20	21⅛	19¾	22	Coast Survey, 1862.
	From Lower Cedar Point to Indian Head	19	20⅛	18¾	21	Coast Survey, 1862–'63.
	From Indian Head to Giesboro' Point	21	23¾	20¾	21½	Coast Survey, 1863.
	From Giesboro' Point to Washington wharves	15	17¾	14¾	18½	U. S. Engineers, 1880.
	From Giesboro' Point to Georgetown wharves	14	16¾	13¾	17½	Do.
	From Giesboro' Point to Buzzard's Point (Eastern Branch)	20	22¾	19¾	23½	Do.
	From Buzzard's Point to Navy-yard (Eastern Branch)	16	18¾	15¾	19½	Do.
	To anchorage in Cornfield Harbor	15	16¼	14¾	17	Coast Survey, 1860.
	In the entrance to Coan River	18	19¼	17¾	20	Coast Survey, 1868.
	Channel into Yeocomico River, and up to Kinsale	8	9¼	7¾	10	Do.
	To anchorage in Yeocomico River off Barn Point	16	17¼	15¾	18	Do.
	Saint Mary's River, from entrance to Saint Mary's	21	22½	20¾	23	Coast Survey, 1857.
	Channel into Saint Inigo's Creek	13	14½	12¾	15	Coast Survey, 1859, '68.
	Channel into Saint George's Creek	14	15½	13¾	16	Do.
	Passage into Lower Machodoc River as far as Glebe Creek	13	14¼	12¾	15	Do.
	To anchorage in Nomini Bay	16	17¼	15¾	18	Do.
	Channel into Breton's Bay up to Leonardtown	8	9¼	7¾	10	Do.
	To anchorage in Breton's Bay, off Protestant Point	14	15¼	13¾	16	Do.
	Channel into Saint Clement's Bay up to Guest's Point	13	14¼	12¾	15	Do.
	Wicomico River, from entrance to Bramleigh's Creek	22	23¾	21¾	24½	Coast Survey, 1860, '68.
	To anchorage in Wicomico River off Lancaster's	18	19¾	17¾	20½	Do.
	Channel to Deep Point, Port Tobacco River	7½	9	7½	9½	Coast Survey, 1862.
	Channel to railroad depot, Aquia Creek	7	8¼	6¾	9	Do.
	At Alexandria wharves	18	20¾	17¾	21½	Coast Survey, 1863.
(Pocomoke Sound)	From off Watts' Island to abreast of Guilford's Flats	21	22¼	20¾	23	Coast Survey, 1855.
	To anchorage under east shore of Watts' Island	14	15¼	13¾	16	Do.
	To the entrance to Pocomoke River	7	8¼	6¾	9	Do.
	Across "The Mud" to Williams' Point, Pocomoke River	3	4¼	2¾	5	Coast Survey, 1869.
	Channel into Messongo Creek	8	9¼	7¾	10	Do.
	Channel into Guilford Creek	7	8¼	6¾	9	Do.
	Channel into Hunting Creek	7	8¼	6¾	9	Do.

Table of depths, Atlantic Coast—Continued.

VIRGINIA AND MARYLAND.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Tributaries to Chesapeake Bay:						
(Tangier Sound)	Passage through the Sound from Watts' Island to abreast of Deil's Island	33	34½	32¾	35	Coast Survey, 1856.
	Through Kedge's Straits into the Sound	9	10½	8¾	11	Do.
	Through Hooper's Straits into the Sound	13	14½	12¾	15	Do.
	Channel to Crisfield Railroad wharf (Little Annemessex River)	8	9½	7¾	10	Coast Survey, 1869.
	To anchorage in Crisfield Harbor near Light-house	8	9½	7¾	10	Do.
	Channel into Big Annemessex River as far as Colburn's Creek	12	13½	11¾	14	Do.
	Up Manokin River to Back Creek	7	8½	6¾	9	Coast Survey, 1859.
	Channel into Fishing Bay as far up as Fishing Point	14	15½	13¾	16	Coast Survey, 1858.
	To anchorage in Fishing Bay off Rose Neck Point	14	15½	13¾	16	Do.
	In the entrance to Nanticoke River	19	20½	18¾	21	Do.
	Up Nanticoke River to Vienna	8	9½	7¾	10	Do.
	To anchorage in Monie Bay	13	14½	12¾	15	Coast Survey, 1859.
	Channel into Wicomico River and up to White Haven	7	8½	6¾	9	Do.
(Honga River)	From entrance to Ben's Point	19	20½	18¾	21	Do.
(Patuxent River)	From entrance to Point Patience	24	25½	23¾	26	Coast Survey, 1848.
	To anchorage under Drum Point	22	23½	21¾	24	Do.
	To anchorage behind Solomon's Island	13	14½	12¾	15	Do.
	From Point Patience to Point Judith	19	20½	18¾	21	Coast Survey, 1857–'59.
	From Point Judith to Trueman's Point	13	14½	12¾	15	Do.
	From Trueman's Point to Lower Marlborough	11	12½	10¾	13	Do.
	From Lower Marlborough to Jones' Point	13	14½	12¾	15	Do.
(Little Choptank River)	From entrance to abreast of Ragged Point	19	20½	18¾	21	Coast Survey, 1871.
	From off Ragged Point to mouth of Church Creek	13	14½	12¾	15	Do.
	Channel into Lee's Creek	6½	8	6¼	8½	Do.
	Into Phillips' Creek as far as Cherry Island	6¼	7¾	6	8¼	Do.
	Up Church Creek to village	6½	8	6¼	8½	Do.
(Choptank River)	Through main entrance, south of Sharp's Island, to abreast of Cook's Point	24	25	23½	25½	Coast Survey, 1847–'48
	Through passage between Sharp's Island and Tilghman's Island to abreast of Cook's Point	15	16	14½	16½	Do.
	From Cook's Point to abreast of Cambridge	19	20	18½	20½	Coast Survey, 1848, '71
	To wharves in Cambridge Harbor	7	8	6½	8½	Do.
	Up the river from Cambridge to abreast of Hunting Creek	13	14	12½	14½	Do.
	Up Tredhaven Creek to Oxford	18	19	17½	19½	Do.
	Up Tredhaven Creek from Oxford to Easton	7	8	6½	8½	Do.
	Channel into Broad Creek up to Hambleton's Island	14	15	13½	15½	Coast Survey, 1848
	Into Harris' Creek and up to Turkey Neck Point	15	16	14½	16½	Do.
(Herring Bay)	To anchorage in outer bay	14	15½	13¾	16	Coast Survey, 1846
	To anchorage in inner bay	7	8¼	6⅔	8¾	Do.
(Eastern Bay)	From entrance to abreast of Tilghman's Point	27	28	26¾	28¼	Coast Survey, 1847
	Up Saint Michael's River to abreast of Saint Michael's	19	20	18¾	20¼	Do.
	To Saint Michael's wharves	9	10	8¾	10¼	Do.
	Up Saint Michael's River to Goldsborough Creek	11	12	10¾	12¼	Do.
	To anchorage behind Tilghman's Point	24	25	23¾	25¼	Do.
	To Bruff's Island, Wye River	19	20	18¾	20¼	Do.

Table of depths Atlantic Coast—Continued.

MARYLAND.

Place.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Tributaries to Chesapeake Bay: (Eastern Bay—Continued)	Channel into Front Wye River up to Pickering's Creek	19	20	18¾	20¼	Coast Survey, 1847.
	Through Back Wye River to Wye Narrows	8	9	7¾	9¼	Do.
	Through Back Wye River to Big Wye River	12	13	11¾	13¼	Do.
	Channel into Coxe's Creek	9	10	8¾	10¼	Do.
	Passage east of Poplar Island	8	9	7¾	9¼	Coast Survey, 1846.
	To anchorage under Kent Point	19	20	18¾	20¼	Do.
(West River)	From entrance to mouth of Rhode River	13	14	12¾	14¼	Do.
	From Rhode River to Gale's Creek	9	10	8¾	10¼	Do.
	Rhode River, from entrance to Water Creek	9	10	8¾	10¼	Do.
(South River)	From entrance to the bridge	15	16	14¾	16¼	Do.
	To anchorage off Turkey Point	15	16	14¾	16¼	Do.
	To anchorage in Selby's Bay	7	8	6¾	8¼	Do.
(Severn River and Annapolis Harbor.)	From entrance to abreast of the city of Annapolis	19	20	18¾	20¼	Coast Survey, 1844, '70.
	To anchorage in Annapolis Roads	22	23	21¾	23¼	Do.
	To anchorage in Annapolis Harbor	13	14	12¾	14¼	Do.
	Up the river from Annapolis to Round Bay	19	20	18¾	20¼	Do.
	To anchorage in Little Round Bay	16	17	15¾	17¼	Do.
	To anchorage between Hackett's Point and Greenbury's Point	18	19	17¾	19¼	Do.
(Magothy River)	From entrance to Huddle's Point	11	11¾	10¾	12	Coast Survey, 1845.
	Channel on west side of Gibson's Island	9	9¾	8¾	10	Do.
	To anchorage inside the entrance	10	10¾	9¾	11	Do.
(Chester River)	Through main entrance north of Love Point Lighthouse	21	22	20⅞	22⅛	Coast Survey, 1846, '70.
	Entrance across shoals south of Love Point Lighthouse	8½	9½	8	9¾	Do.
	To anchorage under Love Point	19	20	18⅞	20⅛	Do.
	Channel up the river to Deep Point	24	25	23⅞	25⅛	Do.
	From Deep Point to Chestertown	9	10	8¾	10¼	Do.
	Channel into Queenstown Creek	4	5	3¾	5¼	U. S. Engineers.
	Into Corsica Creek up to Emory's Cove	10	11	9¾	11¼	Coast Survey, 1846, '70.
	Channel into Grey's Inn Creek	11	12	10¾	12¼	Do.
	Langford's Creek to "The Forks"	8	9	7¾	9¼	Do.
(Patapsco River and Baltimore Harbor.)	Through the Craighill Channel	24	25¼	23¾	25½	U. S. Engineers, 1874.
	Through the Brewerton Channel	24	25¼	23¾	25½	Do.
	From Brewerton Channel to Lazaretto Point	24	25¼	23¾	25½	Coast Survey, 1880.
	Into Baltimore Harbor and up to main wharves at Locust Point	24	25¼	23¾	25½	Do.
	To Fell's Point wharves	20	21¼	19¾	21½	Do.
	To head of "The Basin"	14	15¼	13¾	15½	Do.
	Channel south of Fort McHenry to Long Bridge (Spring Garden)	13	14¼	12¾	14½	Do.
	Channel into Rock Creek	11	12¼	10¾	12½	Coast Survey, 1869.
	Into Stony Creek	14	15¼	13¾	15½	Do.
	Entrance to Curtis' Creek	21	22¼	20¾	22½	Do.
	Up Curtis' Creek to Marley Creek	19	20¼	18¾	20½	Do.
	To anchorage in Old Road Bay	13	14¼	12¾	14½	Do.
	Up Beard Creek to Long Point	14	15¼	13¾	15½	Do.
	Channel into Humphrey's Creek	12	13¼	11¾	13½	Do.
(Back River)	Through Hawk Cove to entrance, and up to Potter's Point	8	9	7¾	9¼	Coast Survey, 1845–'46
	Up to railroad bridge	5	6	4¾	6¼	Do.
	To anchorage in Hawk Cove	8	9	7¾	9¼	Do.
(Middle River)	From entrance to Galloway's Creek	8	9	7¾	9¼	Do.
	To anchorage off Turkey Point	10	11	9¾	11¼	Do.

Table of depths, Atlantic Coast—Continued.

MARYLAND VIRGINIA, AND NORTH CAROLINA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Tributaries to Chesapeake Bay:						
(Gunpowder River)	From entrance to railroad bridge	6	7	5¾	7¼	Coast Survey, 1846.
	To anchorage off Carroll's Point	10	11	9¾	11¼	Do.
(Bush River)	From entrance to railroad bridge	7	8	6¾	8¼	Do.
	To anchorage off Sandy Point	11	12	10¾	12¼	Do.
(Sassafras River)	Channel to Fredericktown	13	14	12¾	14¼	Coast Survey, 1847 '70.
	To anchorage close under Ordinary Point	13	14	12¾	14¼	Do.
(Elk River)	From entrance to mouth of Bohemia River	18	19	17¾	19¼	Coast Survey, 1846.
	From Bohemia River to Court-house Point	16	17	15¾	17¼	Do.
	From Court-house Point to Elkton Landing	6	7	5¾	7¼	Do.
	Up Bohemia River to Stony Point	7	8	6¾	8¼	Do.
	Channel up Back Creek to Chesapeake City	7	8	6¾	8¼	Do.
	To anchorage above Turkey Point	16	17	15¾	17¼	Do.
(Northeast River)	Channel to Charlestown	7	8¼	6¾	8½	Coast Survey, 1846.
	To anchorage off Red Point	12	13¼	11¾	13½	Do.
(Susquehanna River)	Channel to Havre de Grace	8	9	7¾	9½	U. S. Engineers, 1870.
	From Havre de Grace to Port Deposit	14	15	13¾	15½	Coast Survey, 1852.
COAST FROM CAPE HENRY TO CAPE LOOKOUT.						
Oregon Inlet*	Over the Bar	6½	8¼	6¼	8½	Coast Survey, 1862.
	From inside the Bar to Pamplico Sound	4¾	6½	4½	6¾	Do.
Hatteras Cove	To anchorage	24	27½	23¾	28	Coast Survey, 1870-'72.
Hatteras Inlet*	Over the Bar	7	10½	6¾	11	Do.
	From inside the Bar to Pamplico Sound	8	11½	7¾	12	Do.
Ocracoke Inlet*	Over the Bar	13	15¼	12¾	15½	Coast Survey, 1877.
	From the Bar into Pamplico Sound	6	8¼	5¾	8½	Do.
Lookout Cove	To anchorage	14	17	13¾	17¼	Coast Survey, 1878.
			No tides.			
Currituck Sound	From Croatan Light-house to Shellbank Point	6	......	......	......	Coast Survey, 1850-'51.
	From Shellbank Point to abreast of Jew's Quarter Island	5½	......	......	......	Do.
	From abreast of Jew's Quarter Island to mouth of North Landing River	2	......	......	......	Do.
	Up North Landing River to Beacon No. 1	7	......	......	......	Coast Survey, 1851, '77.
	To Currituck Steamboat Landing	3½	......	......	......	Do.
ALBEMARLE SOUND and Tributaries.	Channel into Cedar Bay	6½	......	......	......	Coast Survey, 1859, '77.
	From Croatan Light-house through the Sound to mouth of Chowan River	11	......	......	......	Coast Survey, 1848-'51.
	From Croatan Light-house to mouth of Pasquotank River	10¾	......	......	......	Do.
	Entrance to North River	6½	......	......	......	Coast Survey, 1850.
	Pasquotank River, from entrance to Elizabeth City	10½	......	......	......	Coast Survey, 1874.
	Channel into Alligator River up to Grapevine Bay	9	......	......	......	Coast Survey, 1876.
	Up Little River to Nixonton	7	......	......	......	Coast Survey, 1848.
	Perquimons River, from entrance to Hertford	9	......	......	......	Do.
	Channel into Scuppernong River and up to Columbia	7½	......	......	......	Coast Survey, 1849.
	Over Bar at mouth of Roanoke River, west of the light-house	12	......	......	......	Coast Survey, 1864.
	Roanoke River, from entrance to Plymouth	13	......	......	......	Do.
	Through Middle River to Roanoke River	10	......	......	......	Do.
	Edenton Bay, from entrance to Edenton	7	......	......	......	Coast Survey, 1849.
	In the entrance to Chowan River	16½	......	......	......	Coast Survey, 1874.
	Up Chowan River from entrance to Etherage's Wharf (West Channel)	15½	......	......	......	Do.

* Shifting sand shoals.

Table of depths, Atlantic Coast—Continued.

NORTH CAROLINA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
ALBEMARLE SOUND and tributaries—Continued.	Up Chowan River from entrance to Holly's Wharf (East Channel)	18				Coast Survey, 1874.
Roanoke Sound	From Oregon Inlet to Broad Creek Point	4				Coast Survey, 1873.
	From Broad Creek Point through the sound to abreast of Mann's Point	6½				Do.
	To abreast of Croatan Light-house	7½				Do.
Croatan Sound	From Oregon Inlet to abreast of Roanoke Marshes Light-house	6				Do.
	From Roanoke Marshes Light-house through the sound to abreast of Croatan Li ht-house	9				Do.
PAMPLICO SOUND and Tributaries.	From abreast of Oregon Inlet to Long Shoal Point Light-house	7				Coast Survey, 1873-'77.
	From Long Shoal Point Light-house through the sound to the entrance to Pamplico River	11				Do.
	From abreast of Hatteras Inlet to entrance to Pamplico River	11				Do.
	From abreast of Ocracoke Inlet to entrance to Pamplico River	10				Do.
	Through the sound to the entrance to Neuse River	12				Coast Survey, 1874-'76.
	Channel into Stumpy Point Bay	5				Coast Survey, 1873-'77.
	In the entrance to Long Shoal River	7½				Coast Survey, 1875-'77.
	To head of Long Shoal River	3				Do.
	To Middleton anchorage	9				Do.
	To anchorage in Juniper Bay	6½				Coast Survey, 1874.
	Channel into Swan Quarter Bay	7				Do.
	Through Swan Quarter Narrows	7				Do.
	Rose Bay, from entrance to Swan Quarter Canal	7				Do.
	Pamplico River, from entrance to Washington	7				Coast Survey, 1871, '72.
	Pungo River, from entrance to Duran's Point	12½				Do.
	Entrance to Mouse Harbor	11				Coast Survey, 1869-'70.
	To anchorage in Mouse Harbor	8				Do.
	Neuse River, from entrance to New Bern	9½				Coast Survey, 1863-'66.
	Bay River, from entrance to Jackson	8				Coast Survey, 1869.
	In the entrance to Cedar Island Bay	9				Coast Survey, 1870.
	In the northern entrance to Core Sound	5½				Do.
	Cedar Island Bay:					
	In entrance*	9				Coast Survey, 1874.
	To anchorage	9				Do.
	At anchorage	12				Do.
	Neuse River:					
	Turn-again Bay, over bar	9				Do.
	Broad Creek, in entrance	11				Do.
	South River, in entrance	11½				Do.
	Adam's Creek, in entrance	12				Do.
	Clubfoot Creek, in entrance	11				Do.
	Clubfoot Creek, to canal	4				Do.
Core Sound	At the southern entrance to the Sound	6				Coast Survey, 1876.
	Through the Sound from Pamplico Sound to entrance to Beaufort Harbor	5½				Do.
	Over Piney Point Shoal	5½				Do.
	Over Harbor Island Bar (at entrance to Pamplico Sound)	5½				Do.
	Hog Island Bay, over bar by Eastern Channel	4½				Do.
	Hog Island Bay, over bar by Southern Channel	7				Do.

NOTE.—Fifteen feet can be taken into this bay; but the channel is narrow and runs close along the dangerous flats, making off from Cedar Island Point, and is dangerous to use.

Table of depths, Atlantic Coast—Continued.

NORTH CAROLINA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Core Sound—Continued	Hog Island Bay, at anchorage	8	......	......	......	Coast Survey, 1876.
	Rumley Bay, to anchorage	4½	......	......	......	Do.
	Thoroughfare Bay, to anchorage	6½	......	......	......	Do.
	Styran's Bay, to anchorage	6½	......	......	......	Do.
	Nelson's Bay, to anchorage	5	......	......	......	Do.
	Jarrett's Bay:					
	At entrance	5¾	......	......	......	Do.
	At anchorage	5	......	......	......	Do.
	Through "The Straits" to Old Topsail Inlet (Beaufort Entrance)	6½	......	......	......	Do.
COAST FROM CAPE LOOKOUT TO CAPE FEAR.						
Old Topsail Inlet (Beaufort Harbor).	Over Bar,* Main Ship Channel	14	16⅔	13¾	17⅙	Coast Survey, 1874.
	To Railroad Wharf, Morehead City	21	23¾	20¾	24¼	Do.
	To Beaufort by way of Bulkhead Channel	4	6¾	3¾	7¼	Do.
	To Beaufort by way of Gallant's Channel	4	6¾	3¾	7¼	Do.
	In Harbor, from Shark Shoal Beacon to mouth of Newport River	8½	11⅓	8	11¼	Do.
	In Harbor, from Shark Shoal Beacon to mouth of Core Creek	6½	9⅓	6⅓	9⅔	Do.
	In Harbor, from Shark Shoal Beacon to entrance to Bogue Sound	15	17¾	14¾	18	Do.
Back Sound	From "The Straits Channel" to Shell Point	10½	......	......	......	Coast Survey, 1876.
	From Shell Point to abreast of Fort Macon	3½	......	......	......	Do.
Bogue Sound	Eastern entrance: †					
	Over Bar to Carolina City	9	11¾	8¾	12¼	Coast Survey, 1874.
	To abreast of Morehead City	13	15¾	12¾	16¼	Do.
	To Morehead City Wharf	2	4¾	1¾	5¼	Do.
New River Inlet	Over Outer Bar	3	4¾	......	......	Coast Survey, 1851.
	At anchorage above Inner Bar	9	10¾	......	......	Do
	In the Channel to New River and Stump Sound	4	5¾	......	......	Do.
CAPE FEAR RIVER	Western Bar Channel: *					
	Over Outer Bar	12	16½	11½	17	Coast Survey, 1872.
	Over Inner Bar	8	12½	7½	13	Do.
	At anchorage between Fort Caswell and Smithville	22½	27	22	27½	Do.
	Eastern or Bald Head Channel,* Over Bar	14	18½	13½	19	Do.
	River Channel from Bald Head Point to Smithville	24	28½	23½	29	Coast Survey, 1872–'73.
	River Channel from Smithville to Federal Point	10	14½	9½	15	Do.
	River Channel from Federal Point to Old Brunswick	11	15½	10¾	15¾	Do.
	River Channel from Old Brunswick to Wilmington	9	11¾	8¾	12¼	Do.
	River Channel from Point Peter to the Bridge	13	15¾	12¾	16¼	Do.
	Northwest Branch: From Point Peter to junction with Brunswick River	19	21¾	18¾	22¼	Do.

*Shifting sand, requires a pilot to cross.

† This Sound cannot be traversed without a pilot.

Table of depths, Atlantic Coast—Continued.

SOUTH CAROLINA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Winyah Bay and Georgetown Harbor.	South Channel*: Over Bar to abreast of the Light-house	6½	10	6½	10½	Coast Survey, 1876.
	Middle Channel: Over Bar to abreast of the Light-house	7½	11	7½	11½	Do.
	Bottle Channel: Over Bar to abreast of the Light-house	6½	10	6½	10½	Do.
	Southeast Channel†: From Georgetown Light-house to Frazier's Point	13	16½	12¾	16¾	Do.
	Same distance by Middle Channel	9	12½	8¾	12¾	Do.
	Same distance by West Channel	10	13½	9¾	13¾	Do.
	From Frazier's Point to Georgetown	10	13½	9¾	13¾	Do.
	Over Bar at entrance to Southeast Channel	7	10½	6¾	11	Do.
South Santee River	From the entrance up to Alligator Creek	5	9	4¾	9½	Coast Survey, 1878.
	At the anchorage	11	15	10¾	15½	Do.
	From Alligator Creek to Pleasant Creek	7	11	6¾	11½	Do.
	From Pleasant Creek to Six-Mile Creek	6	10	5¾	10½	Do.
	From Six-Mile Creek to Causeway Canal	2	6	1¾	6½	Do.
	Passage through Causeway Canal	½	4½	¼	5	Do.
	Passage through Six-Mile Creek	9	13	8¾	13½	Do.
	Dark Creek and Canal to North Santee	3	7	2¾	7½	Do.
	Passage through Pleasant Creek	6½	10½	6¼	11	Do.
	Passage through Alligator Creek	3	7	2¾	7½	Do.
North Santee River	From the entrance to Big Duck Creek	6½	8	6¼	8½	Do.
	At the anchorage	11	12¾	10¾	12¾	Do.
	From Big Duck Creek to Causeway Canal	12½	14	12¼	14½	Do.
	Passage through Big Duck Creek	5	6¾	4¾	6¾	Do.
	Passage through Atchison Creek to South Santee.	3	4¾	2¾	4¾	Do.
	Passage through Upper Branch of Big Duck Creek	4½	6	4¼	6½	Do.
	Passage from North Santee Bay to Minim Creek.	3½	5	3¼	5½	Do.
	Passage through Minim Creek to North Santee River	6½	8	6¼	10	Do.
	Passage through Bella Creek to North Santee River	1½	3	1¼	7	Do.
Cape Romain and vicinity	Alligator Creek: From entrance to South Santee River	3	7¾	2¾	8¾	Coast Survey, 1874.
	Passage through "The Needles"	5	9¾	4¾	10¾	Do.
	Casino Creek: From entrance to Duck Creek	4	8¾	3¾	9¾	Do.
	Congarre Boat Creek to Mud Bay	14	18¾	13¾	19¾	Do.
	From Mill Creek to "The Needles"	2	6¾	1¾	7¾	Do.
	Channel between Devil's Den and Mill Den from entrance to Oyster Bay	9½	14½	9	15½	Do.
	At the anchorage	16	20¾	15¾	21¾	Do.
	Passage through Oyster Bay	6½	11½	6	12½	Do.
	Passage through Ram's Horn Creek	½	5½	¼	6½	Do.
Cape Romain River	At the entrance	8	12¾	7¾	13¾	Do.
	At the anchorage	15	19½	14¾	20¾	Do.
	From the entrance to Five-Fathom Creek	7½	12½	7	13½	Do.
	Passage through Sett Creek	3½	8½	3	9½	Do.
	From the river through Clark's Creek to its mouth	1½	6½	1	7½	Do.
	Passage through Bay Creek	3½	8½	3	9½	Do.
	Passage through Key's Creek	6	10¾	5¾	11¾	Do.

*Shifting sand-bar.

†The Southeast Channel is the only one buoyed; and is the safest and most direct.

Table of depths, Atlantic Coast—Continued.

SOUTH CAROLINA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Bull's Bay and tributaries	At the anchorage inside of Bird Island	8½	13⅓	8	13¾	Coast Survey, 1859.
	Bull's Harbor:					
	Over the Bar*	17	21¾	16¾	22¾	Do.
	At the anchorage	25	29¾	24¾	32¾	Do.
	From entrance to Bull Creek	7	11¾	6¾	12¾	Do.
	Bull Creek: Through creek to Sewee Bay	7	11¾	6¾	12¾	Coast Survey, 1875.
	Bull Narrows: Through to Price's Inlet	4½	9⅓	4	10¼	Do.
	Sewee Creek:					
	Over the Bar*	8	12¾	7¾	13¾	Coast Survey, 1859.
	Through creek to Sewee Bay	7	11¾	6¾	12¾	Coast Survey, 1875.
	Van Ross Creek: through creek to Sewee Bay	7	11¾	6¾	12¾	Do.
	Belvedere Creek, over Bar	1	5¾	......	......	Coast Survey, 1859.
	Salt Pond Creek, over Bar	0	4¾	½	5⅓	Do.
	Graham's Creek, over Bar	1	5¾	½	6½	Do.
	Five Fathom Creek:					
	Over Bar	3	7¾	2¾	8½	Do.
	Up to Town Creek	14	18¾	13¾	19½	Coast Survey, 1875.
	Through to Oyster Bay	½	5⅓	0	5¾	Do.
	Bull River:*					
	Over Bar	½	5⅓	¼	5¾	Coast Survey, 1859.
	To Five Fathom Creek	6½	11⅓	6	11¾	Coast Survey, 1875.
	Sett Creek from Bull River to Five Fathom Creek	3½	8⅓	3	8¾	Do.
	Long Creek, over Bar	3	7¾	2½	8¼	Do.
	Harbor River:					
	Over Bar	1	4¾	¾	5	Coast Survey, 1859.
	At the anchorage	16½	20¼	16¼	20¾	Coast Survey, 1875.
	Channel to Matthew's Cut	7	10¾	6¾	11	Do.
	Owendaw Creek:					
	Over Bar	1	5¾	¾	6⅓	Coast Survey, 1859.
	From mouth to Head Bridge	1½	6⅓	1	6½	Coast Survey, 1875.
Price's Inlet	Over Bar*	7	11¾	6¾	12¾	Coast Survey, 1857.
	From entrance to Clauson Creek	14	18¾	13¾	19¾	Coast Survey, 1875.
	Through to Sewee Bay	2½	7⅓	2	8¼	Do.
Santee Pass	From Price's Inlet to Caper's Inlet	2	6¾	1¾	7¾	Do.
Caper's Inlet	Over Bar*	5	9¾	4¾	10¾	Coast Survey, 1857.
	From entrance to Toomer's Creek	8	12¾	7¾	13¾	Coast Survey, 1875.
	Info Bull-yard Sound	4	8¾	3¾	9¾	Do.
	Passage through Bull-yard Sound	1	5¾	¾	6¾	Do.
	Passage through Caper's Creek to Mark Bay	6	10¾	5¾	11¾	Do.
	Through Toomer's Creek to Copahee Sound	6½	11⅓	6	12¼	Do.
	Passage through Copahee Sound	½	5⅓	0	6¼	Do.
Dewees Inlet	Over Bar*	5	9¾	4¾	10¾	Coast Survey, 1857.
	From entrance to Long Creek	23	27¾	22¾	28¾	Coast Survey, 1875.
	Through the Seven Reaches to Gray's Bay	7	11¾	6¾	12¾	Do.
	Through Long Island Narrows to Breach Inlet	½	6	0	6¾	Do.
	Through Pushee Creek to Copahee Sound	6	11¾	5½	12¼	Do.
	Through Pushee Creek to Hamlin Sound	6	11¾	5½	12¼	Do.
	Into Bull-yard Sound	9	14¾	8½	15¼	Do.
	Through Dewees' Creek to Hamlin Sound	12	17¾	11½	18¼	Do.
	Through Long Creek to Gray's Bay	6	11¾	5½	12¼	Do.
Breach Inlet	Over Bar*	4	8¾	3¾	9¾	Coast Survey, 1857
	Through Swinton's Creek to Hamlin Sound	1	5¾	¾	6¾	Coast Survey, 1875
	Through Hamlin Creek to Gray's Bay	1	5¾	¾	6¾	Do.
	Through Conch Creek to Inlet Creek	0	4¾	— ¼	5¾	Do.
	Through Inlet Creek to Swinton's Creek	2	6¾	1¾	7¾	Do.

* Shifting sand-bar.

Table of depths, Atlantic Coast—Continued.

SOUTH CAROLINA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
CHARLESTON HARBOR ...	Over Bar* by Pumpkin Hill Channel	11	16	10¾	16¾	Coast Survey, 1865.
	Over Bar by Main Ship Channel.........	10	15	9¾	15¾	Do.
	Over Bar by South Channel	14	19	13¾	19½	Do.
	Over Bar by Middle Channel	12½	17½	12	18	Do.
	Over Bar by Beach Channel	12	17	11¾	17½	Do.
	Main Ship Channel from inside Bar to Fort Moultrie	18	23	17¾	23½	Coast Survey, 1869.
	South Channel from inside Bar to City.....	21	26	20¾	26½	Coast Survey, 1865.
	Folly Island Channel from Rebellion Roads to the City	14	19	13¾	19½	Do.
	Hog Island Channel from Rebellion Roads to the City..	15	20	14¾	20½	Do.
	Over the Bar by Swash Channel	12½	17½	12	18	Do.
	Swash Channel from inside Bar to City	15½	20½	15½	21	Do.
	At the anchorage in Rebellion Roads	32	37	31¾	37½	Do.
	Throu, h Ashley River to the Bridge	21	26	20¾	26½	Do.
	Through Cooper River to upper end of Drum Island	30	35	29¾	35½	Do.
	Through Town Creek to upper end of Drum Island	23	28	22¾	28½	Do.
	Through the Cove Channel to Moultrieville Bridge	8	13	7¾	13½	Coast Survey, 1865.
Light-House Inlet	Over Bar*..	3	8	2¾	8½	Coast Survey, 1863–'64.
	At the anchorage near Inner Beacon.........	18	24	17¾	23½	Do.
Stono Inlet and River..........	Over Bar*..	6½	12½	6	13	Coast Survey, 1862.
	At the anchorage off Cole's Island	24	30	26¾	33½	Do.
	Through Stono River to Entrance to Wappoo Creek	15	20	14¾	20½	Do.
	Through Wappoo Creek to Ashley River	2	7	1¾	7½	Do.
	Kiawah River Entrance	21	26	20¾	26½	Do.
	Folly Island River to anchorage off Secessionville.	10	15	9¾	15½	Do.
North Edisto River............	Over Bar* by North Channel........................	11	16¾	10¾	17½	Coast Survey, 1856.
	Over Bar by Southwest Channel	12	17¾	11¾	18½	Do.
	To Entrance to Wadmelaw River..................	19	24¾	18¾	25½	Coast Survey, 1851.
	Up Bohicket Creek to Rockville....................	16	21¾	15¾	22½	Do.
	Up Steamboat Creek to Mud Flat	10	15¾	9¾	16½	Coast Survey, 1875–'76.
	Through Dawho River to South Edisto River.....	6	11¾	5¾	12½	Do.
South Edisto River	Over the Bar*	13	19	12½	19¾	Coast Survey, 1856–'57.
	At the anchorage above Bay Point................	27	33	26½	33¾	Coast Survey, 1876.
	Up river to Entrance to Dawho River	8	14	7½	14¾	Do.
	Up Saint Fierre's Creek to Peter's Point..........	11	17	10½	17¾	Do.
Saint Helena Sound and Tributaries.	Over Bar by Main Channel..........................	16	22	15½	22¾	Coast Survey, 1856–'57.
	Over Bar* by East Channel..........................	10	16	9½	16¾	Do.
	Over Bar* by South Channel	16	22	15½	22¾	Do.
	Channel into Morgan River	15	21	14½	21¾	Do.
	Passage from Harbor River to Morgan River	8	14	7½	14¾	Do.
	Along shore from the Sound to South Edisto River	9	15	8½	15¾	Coast Survey, 1876.
	Up Harbor River to Tripp's Inlet	10	16	9½	16¾	Coast Survey, 1863.
	Morgan River:					
	Up river to Lucy Point	17½	23½	16¾	24½	Coast Survey, 1860, 1872.
	Up river to Bridge	½	6½	— ½	7½	Do.
	Up Lucy Creek to Coosaw River..................	8	14	7½	14¾	Coast Survey, 1872.
	Through Parrott Creek to Coosaw River..........	14	20	13½	20¾	Coast Survey, 1860.
	Coosaw River:					
	From Entrance to Bull River	19	25	18½	25¾	Do.
	Through to Brickyard Creek	9	15	8½	15¾	Do.
	From Brickyard Creek to Port Royal Ferry	8	14	7½	14¾	Coast Survey, 1873.
	Through Brickyard Creek to Beaufort River	8	14	7½	14¾	Coast Survey, 1860.

* Shifting sand-bar.

Table of depths, Atlantic Coast—Continued.

SOUTH CAROLINA AND GEORGIA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Saint Helena Sound and Tributaries—Continued.	Through Whale Branch to Broad River	8	14	7⅓	14¾	Coast Survey, 1865–'73.
	Ashepoo River: to Rock Creek Entrance	12	18	11⅓	19½	Coast Survey, 1873.
	Up Combahee River to Old Cheehaw Creek	11	17	10⅓	18½	Coast Survey, 1871–'73.
	Through Cheehaw Creeks	1	7	⅓	8½	Do.
	Up Bull River to Williams' Island	14	20	13⅓	21½	Coast Survey, 1873.
Fripp's Inlet	Over the Bar*	4	10¾	3½	11¼	Coast Survey, 1856–'57.
	Through the Inlet to Harbor River	8	14¾	7½	15¼	Coast Survey, 1863.
	Through Story River to Trenchard's Inlet	6	12½	5½	13¼	Do.
Trenchard's Inlet	Over the Bar*	10	16¾	9½	17¼	Do.
	Through the Inlet to the mouth of Station Creek	18	24¾	17½	25¼	Do.
	Through Station Creek to Port Royal Sound	6	12¾	5½	13¼	Do.
PORT ROYAL SOUND and Tributaries.	Over Bar by East Channel†	16	22¾	15½	23¼	Do.
	Over Bar by Southeast Channel	21	27¾	20½	28¼	Do.
	Over Bar by South Channel	19	25¾	18½	26¼	Do.
	At the anchorage off Hilton Head	48	54¾	47½	55¼	Coast Survey, 1862–'63.
	At the anchorage off Bay Point	42	48¾	41½	49¼	Do.
	Up Beaufort River to Beaufort	13	19¾	12½	20¼	Coast Survey, 1862.
	Up Broad River to Whale Branch‡	13	19¾	12½	20¼	Do.
	Up Broad River to Pocotaligo	9	15¾	8½	16¼	Coast Survey, 1865.
	Chechessee River to upper end of Lemon Island	7	13¾	6½	14¼	Coast Survey, 1859, 1870.
	Colleton River to Callawassie Island	19	25¾	18½	26¼	Do.
	Skull Creek to Calibogue Sound	17	24	16½	25	Coast Survey, 1861–'62.
Calibogue Sound	Over Bar* from Tybee Light	9	16	8½	17	Coast Survey, 1862–'66.
	From inside Bar to May River	19	26	18½	27	Coast Survey, 1862.
	Up May River to Bluffton	12	19	11½	20	Coast Survey, 1870.
	Up Cooper River to New River	12	19	11½	20	Do.
	From Cooper River through Bull's Creek, to May River	6	13	5½	14	Do.
	From Cooper River through Rams-horn Creek to New River	7	14	6½	15	Do.
New River	Over Bar	9	16	8½	17	Do.
	Through to Cooper River	12	19	11½	20	Do.
TYBEE ROADS AND SAVANNAH RIVER.	Over Bar by North Slue Channel	15	22	14½	23	Coast Survey, 1875.
	Over Bar by Main Channel	17	24	16½	25	Do.
	At the anchorage in The Roads	22	29	21½	30	Do.
	Up Savannah River to the City	9	16	8½	17	Coast Survey, 1874.
	Through Lazaretto Creek to Tybee River	7	14	6½	15	Coast Survey, 1863.
	Up Wright's River to Wall's Cut	7	14	6½	15	Coast Survey, 1874.
	Through Saint Augustine's Creek to Tybee River	10	17	9½	18	Do.
Wassaw Sound and tributaries	Over Bar*	14	21¾	13½	22	Coast Survey, 1864.
	At the anchorage off Wassaw Island	25	32¾	24½	33	Coast Survey, 1863.
	Tybee River:					
	Over Bar from Wassaw	10	17¾	9½	18	Do.
	To junction with Saint Augustine's Creek	13	20¾	12½	21	Do.
	Wilmington River, from the Sound to mouth of Skiddaway River	21	28¾	20½	29	Coast Survey, 1865.
	Wilmington River, through to Savannah River	10	17¾	9½	18	Do.
	Skiddaway River, through to Vernon River	1	8¾	½	9	Do.
	Passage through Turner's Creek to Tybee River	7	14¾	6½	15	Do.
	Romerly Marsh Creek to Odingsell River	4	11¾	3½	12	Coast Survey, 1856.
	Through Adams' Creek to Ossabaw Sound	8	15¾	7½	16	Coast Survey, 1860.

* Shifting sand-bar.
† Not buoyed, and unsafe.
‡ Twenty feet at low water can be taken abreast of Whale Branch, but the channel is narrow, crooked, and can be used only by steamers.

Table of depths, Atlantic Coast—Continued.

GEORGIA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Ossabaw Sound and tributaries	Over Bar* by North Channel	9	15¾	8⅓	16¼	Coast Survey, 1860.
	Over Bar* by South Channel	15	21¾	14⅓	2 ¼	Do.
	Up Vernon River to Little Ogeechee River	31½	38¼	30¾	38¾	Coast Survey, 1865.
	Up Vernon River to Burnside's River	15	21¾	14⅓	22¼	Do.
	Through Burnside's River and Skiddaway Narrows to Skiddaway River	1	7¾	⅓	8¼	Do.
	Up Burnside's River to Cedar Hammock Creek	8	14¾	7⅓	15¼	Do.
	Up Vernon River to Vernonburg	13	19¾	12⅓	20¼	Do.
	Up Little Ogeechee River to mouth of Forrest River	15	21¾	14⅓	22¼	Do.
	Through Harvey's Cut from Little Ogeechee to Ogeechee River	1	7¾	⅓	8¼	Do.
	Through Hell-Gate from Vernon River to Ogeechee River	4	10¾	3⅓	11¼	Do.
	Up Ogeechee River to Harvey's Cut	7	13¾	6⅓	14¼	Do.
	Through "Florida Passage" to Bear River	10	16¾	9⅓	17¼	Do.
	Anchorage in Vernon River off Raccoon Key	30	36¾	29⅓	37¼	Do.
	Through the Sound to mouth of Vernon River	11	17¾	10⅓	18¼	Coast Survey, 1860.
Saint Catharine's Sound and tributaries.	Over Bar*	12	19½	11¾	20	Coast Survey, 1867.
	Through the Sound to mouth of Medway River	19	26½	18¾	27	Do.
	At the anchorage off Walburg Creek	36	43½	35¾	44	Do.
	Up Bear River to its junction with Florida Passage	10	17½	9¾	18	Do.
	Up Bear River to Kilkenny Creek	21	28½	20¾	29	Do.
	Up North Newport River to its junction with South Newport River	4	11½	3¾	12	Do.
	Through Walburg Creek to North Newport River	6	13½	5¾	14	Do.
	Through Timmons' River to South Newport River	4	11½	3¾	12	Do.
	Through Cedar Creek from the Sound to Medway River	1	8½	¾	9	Do.
	Through Johnson's Creek from North Newport River to Sapelo Sound	8	15½	7¾	16	Do.
	Through Moll Clark's River from North to South Newport River	10	17½	9¾	18	Do.
Sapelo Sound and tributaries	In the entrance	18	25	17⅓	25¾	Coast Survey, 1859.
	Through the Sound to mouth of Sapelo River	33	40	32⅓	40¾	Coast Survey, 1858.
	Through South Newport River to its junction with North Newport	4	11	3⅓	11¾	Coast Survey, 1867.
	At the anchorage off northern end of Blackbeard Island	30	37	29⅓	37¾	Do.
	Through Mud River to Old Teakettle Creek	5	12	4⅓	12¾	Coast Survey, 1868.
	Through Old Teakettle Creek to Doboy Sound	6	13	5⅓	13¾	Do.
	Through Mud River to New Teakettle Creek	5	12	4⅓	12¾	Do.
	Through New Teakettle Creek to Doboy Sound	8	15	7⅓	15¾	Do.
	Up Julienton River to Broro River	10	17	9⅓	17¾	Coast Survey, 1858.
	Through Broro River to Sapelo River	2	9	1⅓	9¾	Do.
	Up Sapelo River to mouth of Broro River	13	20	12⅓	20¾	Do.
Doboy Sound and tributaries	Over Bar*	13½	20¼	12¾	21¼	Coast Pilot and Light-house Board, 1878-'82.
	At the anchorage abreast of Sapelo Light	21	28¼	20⅓	29	Do.
	Through the Sound to abreast of Grassy Point	22½	29¾	22	30¾	Coast Survey, 1868.
	Up Duplin River to Jack's Hammock	11	18¼	10⅓	19	Do.
	Through Beacon Creek to Wolf Creek	4	11¼	3⅓	12	Do.
	Up South River to Wolf Creek	11	18¼	10⅓	19	Do.
	Through Wolf Creek to Beacon Creek	8	15¼	7⅓	16	Do.
	Up South River to Little Mud River	5	12¼	4⅓	13	Do

* Shifting sand-bar.

Table of depths, Atlantic Coast—Continued.

GEORGIA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Doboy Sound and tributaries—Continued.	Through Little Mud River to Altamaha Sound	5	12¼	4⅓	13	Coast Survey, 1868.
	Up South River to Rockdedundy River	5	12¼	4⅓	13	Do.
	Through Rockdedundy to Darien River	6	13¼	5⅓	14	Do.
	Up Darien River to Darien	8	15¼	7⅓	16	Coast Survey, 1872.
	Up Back River to North River	8	15¼	7⅓	16	Coast Survey, 1868.
	Through Back River to South River	8	15¼	7⅓	16	Do.
	Through Back River to Darien River	10	17¼	9⅓	18	Do.
	Through Back River to Rockdedundy River	8	15¼	7⅓	16	Do.
	Up North River to May Hall Creek	10	17¼	9⅓	18	Do.
	Through May Hall Creek to Darien River	4	11¼	3⅓	12	Do.
	Up North River to Catfish Creek	8	15¼	7⅓	16	Do.
	Through Catfish Creek to Darien River	4	11¼	3⅓	12	Do.
	From North River up Darien River to Darien	8	15	7⅓	15¾	Coast Survey, 1872.
	Through New Teakettle Creek to Mud River	8	15	7⅓	15¾	Coast Survey, 1868.
	Through Old Teakettle Creek to Mud River	6	13	5⅓	13¾	Do.
	Up Doboy River to Connegan River	13	20¼	12⅓	21	Do.
	Through Connegan River to North River	8	15¼	7⅓	16	Do.
	Up Doboy River to Hudson's Creek	13	20¼	12⅓	21	Do.
	Up Atwood's Creek to Bay of Islands	11	18¼	10⅓	19	Do.
Altamaha Sound and tributaries.	Over Bar* by Main Channel	11	18¼	10⅓	19	Coast Survey, 1860.
	Over Bar* by Buttermilk Channel	7	14¼	6⅓	15	Do.
	At anchorage under Little Saint Simon's Island	30	37¼	29⅓	38	Do.
	From the Sound to the mouth of Little Mud River	8	15¼	7⅓	16	Do.
	Through the Sound to mouth of Altamaha River	4	11¼	3⅓	12	Coast Survey, 1872.
	Up Altamaha River to Butler's Island	4	11¼	3⅓	12	Do.
	Through Wood Cut to South Altamaha River	4	11¼	3⅓	12	Do.
	Through the Sound to Buttermilk Sound	9	16¼	8⅓	17	Do.
	Through Buttermilk Sound to junction of South Altamaha and Frederica Rivers	8	15¼	7⅓	16	Do.
	Up South Altamaha to Wood Cut	7	14¼	6⅓	15	Do.
	Through Frederica River to Saint Simon's Sound	8	15¼	7⅓	16	Do.
	Through Mackay's River to Saint Simon's Sound	9	16¼	8⅓	17	Do.
Hampton River	Over Bar*	5	12¼	4⅓	13	Coast Pilot, 1877.
	Through to Frederica River	10	17¼	9⅓	18	Coast Survey, 1860.
	Passage through Village Creek to Black Bank River	13	20¼	12⅓	21	Do.
	Through Black Bank River to sea	1	8¼	⅓	9	Do.
Saint Simon's Sound and tributaries.	Over Bar*	16	23	15½	23½	Coast Survey, 1872.
	At the anchorage southwest of the Light-house	35	42	34½	42½	Coast Survey, 1856–'57.
	Through the Sound to Mouth of Frederica River	13	20	12½	20½	Do.
	Through the Sound to mouth of Mackay's River	23	30	22½	30½	Coast Survey, 1872.
	Up Brunswick River to mouth of Turtle River	24	31	23½	31½	Do.
	Up Brunswick River to Brunswick	9	16	8½	17	Coast Survey, 1856.
	Up Turtle River to Hermitage Point	13	20	12½	21	Coast Survey, 1856–'57.
	Through Jekyl Creek to Jekyl Sound	3	10	2½	11	Do.
	Through Cedar Hammock Creek to Jointer's Creek	2	9	1½	10	Do.
	Through Jointer's Creek to Jekyl Sound	2	8¾	1½	9⅓	Coast Survey, 1870.
	Through Back River to Mackay's River	4	11	3½	11⅓	Coast Survey, 1872.
Saint Andrew's and Jekyl Sounds.	Over Saint Andrew's Bar*	15	21¾	14½	22⅓	Coast Survey, 1869.
	At the anchorage under Little Cumberland Island	25½	32¼	25	32¾	Coast Survey, 1870.
	At the anchorage in Jekyl Sound under west shore of Jekyl Island	31½	38¼	31	38¾	Do.
	Through Cumberland River to Cumberland Sound	6¼	13	5¾	13⅓	Do.
	Through Brick-kiln River to Cumberland River	6	12¾	5½	13⅓	Do.
	Through Jekyl Sound to Jekyl Creek entrance	18	24¾	17½	25⅓	Do.

*Shifting sand-bar.

Table of depths, Atlantic Coast—Continued.

GEORGIA AND FLORIDA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Saint Andrew's and Jekyl Sounds—Continued.	Through Jekyl Sound to Jointer's Creek entrance	14	20¾	13½	21½	Coast Survey, 1870.
	Through Jekyl Sound to Little Satilla River	16	22¾	15½	23½	Do.
	Up Little Satilla River to Upper Marsh Island	12	18¾	11½	19½	Do.
	Up Satilla River and over "The Bulkhead"	8	14¾	7½	15½	Do.
CUMBERLAND SOUND and tributaries.	Over Bar* (channel in 1881)	11	17	10½	17½	Coast Survey, 1881.
	Anchorage in mouth of Amelia River	30	36	29½	36½	Coast Survey, 1855–'57.
	Through the Sound to mouth of Saint Mary's River	25½	31½	25	31¾	Do.
	Through the Sound to King's Bay	11	17	10½	17½	Do.
	Up Saint Mary's River to Saint Mary's	17	23	16½	23½	Coast Survey, 1871.
	Up King's Bay to Marianna Creek	11	17	10½	17½	Coast Survey, 1855–'57.
	Through the Sound to Crooked River	14	20	13½	20½	Do.
	Through the Sound to junction with Cumberland River	6½	12½	5¾	12½	Coast Survey, 1855–'57.
	Through the Sound to mouth of Brick-kiln River	7	13	6½	13½	Do.
	Up Jolly River (Florida) to Saint Mary's River	2	8	1½	8½	Coast Survey, 1871.
	Up Amelia River to Fernandina	28	34	27½	34½	Coast Survey, 1857.
	Up Amelia River to Lanceford Creek	16	22	15½	22½	Do.
	Bell's River from Amelia to Jolly River	2	8	1½	8½	Do.
	Bell's River from Amelia to Saint Mary's River	2	8	1½	8½	Do.
	Amelia River to Kingsley's Creek	14	20	13½	20½	Do.
	Through Kingsley's Creek to South Amelia River	1	7	½	7½	Do.
Nassau Sound and tributaries	Over Bar† by the North Channel	4	9½	3¾	9¾	Coast Survey, 1871.
	Over Bar† by the South Channel	10	15½	9¾	15¾	Do.
	At the anchorage under western shore of Amelia Island	24	29⅓	23¾	29¾	Do.
	Up South Amelia River to Alligator Creek	9	14½	8¾	14¾	Do.
	Through South Amelia River to Cumberland Sound	1	6⅓	¾	6¾	Do.
	Through Alligator Creek to Nassau River	7	12⅓	6¾	12¾	Do.
	Up Nassau River to Sterrett's Creek	13	18½	12¾	18¾	Do.
	Through Sterrett's Creek to Pumpkin Hill Creek	3	8½	2¾	8¾	Do.
	Up Pumpkin Hill Creek to junction with Sterrett's Creek	8	13½	7¾	13¾	Do.
	Through Sawpit Creek by Gunnison's Cut to Fort George Inlet	½	5¾	½	6½	Coast Survey, 1870.
	Passage through Back River	6½	11¾	6½	12½	Coast Survey, 1871.
	Through Horsehead Creek to Alligator Creek	6½	11¾	6½	12½	Do.
Fort George Inlet	Over Bar†	4	9½	3¾	9¾	Coast Survey, 1857.
	Through Sawpit Creek to Nassau Sound	½	6	½	6½	Coast Survey, 1870.
	Through Sister's Creek to Saint John's River	1	6½	¾	6¾	Coast Survey, 1870.
SAINT JOHN'S RIVER	Over Bar‡ (channel of 1879)	8	12½	7½	12¾	Coast Survey, 1879.
	To abreast of Great Marsh Island	14	18½	13½	18¾	Coast Survey, 1855.
	At the anchorage off Pilot-houses	36	40⅓	35½	40¾	Coast Survey, 1857.
	At the anchorage at Mayport Mills	24	28½	23½	28¾	Do.
	Through the North Channel to Dames' Point Light-house	13	14	12¾	14½	Coast Survey, 1855.
	Up to Jacksonville	12	13	11¾	13½	Do.
	From Jacksonville to abreast of Green Cove Springs	14½	15½	14	15½	Coast Survey, 1876–'77
	Up to wharf at Green Cove Springs	7	8	6¾	8½	Do.
	From Green Cove Springs to Tocoi (terminus of Saint John's and Saint Augustine Railroad)	10	10¾	10	10¾	Coast Survey, 1878.
	From Tocoi to Pilatka	8	8½	8	8¾	Do.
	From Pilatka to Welaka	7	No tides.			Do.
	From Welaka to Lake George	7	..	......	......	Do.
	Through Lake George and up to Volusia	7½	......	......	......	Do.

* This bar shifts so often both in direction and depth that no soundings reliable for any length of time can be given.
† Shifting sand-bar.
‡ The depths on these two bars cannot be depended on for any length of time. The bars shift constantly both in depth and direction

Table of depths, Atlantic Coast—Continued.

FLORIDA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
SAINT JOHN'S RIVER—Continued.	From Volusia to Lake Monroe	8		No tides.		Coast Survey, 1878.
	Through Lake Monroe to Enterprise Wharf	6½	......	......	......	Do.
	From Enterprise to Sanford Wharf	8	......	......	......	Do.
	Through Lake Monroe to Sanford Wharf	7	......	......	......	Do.
Saint Augustine Inlet	Over Bar* by North Channel	7½	11¾	7	12	Coast Survey, 1870.
	Over Bar* by South Channel	10	14¼	9½	14½	Do.
	At the anchorage behind North Beach	26	30¼	25½	30½	Do.
	Up to City Wharves	13	17¼	12¾	17½	Do.
	Through North River to Guano River	18	22¼	17¾	22½	Do.
	Through North River to Cooper's Landing	6½	10¾	6	11	Do.
	Up Guano River to "Big Sand-hill" (triangulation point of Coast Survey)	5	9¼	4½	9⅓	Do.
	Up Matanzas River to San Sebastian River	14	18¼	13½	18⅓	Do.
	Through Matanzas River to Matanzas Inlet	2	6¼	1¾	6⅓	Do.
	Up San Sebastian River to the Town Wharf	6½	10¾	6	11	Do.
Mosquito Inlet	Over Bar†	5	7¼	4¾	7¾	Coast Survey, 1875.
	Up Halifax River to Pelican Island	5½	6	5½	6⅓	Coast Survey, 1874.
	Up Halifax River to abreast of Daytona	4½	5	4½	5⅓	Do.
	Up Halifax River to its head	2	2½	2	2¾	Do.
	From Halifax River through Narrows to Rose Bay	1	1¼	1	1⅓	Do.
	From Halifax River through Narrows to Strickland Bay	1½	2	1½	2⅓	Do.
	From Halifax River through Narrows to Turnbull Bay	1½	2	1½	2⅓	Do.
	Up Hillsborough River from the Inlet to abreast of New Smyrna	8	11	7¾	11⅓	Do.
	Through Mosquito Lagoon to Turtle Mound	4	4¼	4	4⅓	Coast Survey, 1875.
	Through Mosquito Lagoon to Swift's Wharf	2½	2¾	2½	2¾	Do.
	Through Mosquito Lagoon to abreast of Boat-house Wharf	3	3¼	3	3⅓	Do.
	Haulover Canal to Indian River	1	1¼	1	1⅓	Do.
Indian River	From Haulover Canal to Arantia	2		No tides.		Coast Survey, 1875–'77.
	From Haulover Canal to Park Grove Wharf	2	......	......	......	Do.
	Down river to Titusville Wharf	2½	......	......	......	Do.
	From Titusville to Curtis'	2	......	......	......	Do.
	From Titusville to mouth of Banana Creek	2	......	......	......	Do.
	From Curtis' to Oleander Point	6½	......	......	......	Do.
	From Oleander Point to Fisherman's Point	9½	......	......	......	Do.
	From Fisherman's Point to Elbow Creek	10½	......	......	......	Do.
	From abreast of Elbow Creek to Turkey Creek	6¾	......	......	......	Coast Survey, 1878.
	From abreast of Turkey Creek to Rock Point	6½	......	......	......	Do.
	From abreast of Rock Point to Duck Point	3½	......	......	......	Coast Survey, 1881.
	From abreast of Duck Point to "The Divide"	3¼	......	......	......	Do.
	From "The Divide" to Crawford's Point	2½	......	......	......	Coast Survey, 1881–'82.
	From abreast of Crawford's Point to Round Island	5	......	......	......	Coast Survey, 1882.
	From abreast of Round Island to Inlet	5	5¼	5	5⅓	Γo.
	Through Inlet to Sea	7	9½	......	......	Coast Survey, 1 81.
Banana River	From entrance (opposite Elbow Creek) to Buck Point	5		No tides.		Coast Survey, 1875–'77.
	From Buck Point to abreast of Home Point	5	......	......	......	Do.
	From abreast of Home Point to head of river at Banana Creek	2	......	......	......	Do.
	Through Banana Creek to Indian River	1	......	......	......	Do.
	Anchorage in New-Found Harbor	6½	......	......	......	Do.

* The depths on these two bars cannot be depended on for any length of time. The bars shift constantly both in depth and direction.

† Shifting sand-bar.

Table of depths, Atlantic Coast—Continued.

FLORIDA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Banana River—Continued	At anchorage under Cape Canaveral	14	19	13	19	Coast Survey, 1875.
Indian River Inlet	Over Bar* by the Northern entrance	1½	4	....	....	Coast Survey, 1861.
	Over Bay* by the Southern entrance	1½	4	....	....	Do.
Key Biscayne Bay	Over Bar* at Bear's Cut	5½	7	5½	7½	Coast Survey, 1876.
	Over Bar* to Buoy No. 2, Main Channel through Reef Passage 1½ miles southeast of Cape Florida	7	8½	7	8¾	Coast Survey, 1853.
	Over Bar by Main entrance, to Red Buoy No. 2	7	8½	7	8¾	Do.
	From Red Buoy No. 2 through North Channel (close to Cape Florida)	7	8½	7	8¾	Coast Survey, 1852.
	From Red Buoy No. 2 through South Channel	9	10½	9	10¾	Do.
	Up the Bay to abreast of Fort Dallas	7	7½	7	7¾	Do.
	Through Cæsar's Creek between Elliott's and Old Rhodes' Keys	8	9½	8	9¾	Coast Survey, 1853.
HAWK CHANNEL (inside Florida Reefs).	Over The Reef toward Soldier's Key	22½	24	22½	24½	Coast Survey, 1852.
	Main entrance from abreast of Virginia Key to Soldier Key	18	19½	18	19¾	Do.
	From abreast of Soldier Key to Cæsar's Creek Bank	13	14½	13	14¾	Do.
	Legaré Anchorage:					
	In entrance from northward	19½	21	19½	21½	Do.
	Entering north of Triumph Reef	20	21½	20	21¾	Do.
	Entering south of Triumph Reef	22	23½	22	23¾	Do.
	At the anchorage	27	28½	27	28¾	Do.
	From Hawk Channel to the anchorage	16	17½	16	17¾	Do.
	From abreast of Cæsar's Creek Bank to Alligator Reef Light-house	13	14½	13	14¾	Coast Survey, 1854–'63.
	Turtle Harbor:					
	Entering from sea	30	31½	30	31¾	Coast Survey, 1852.
	Entering from Hawk Channel	16	17½	16	17¾	Do.
	At the anchorage	28½	30	28½	31¾	Do.
	From abreast of Alligator Reef to Long Key	16	17½	16	17¾	Coast Survey, 1860–'62.
	From abreast of Long Key to "East Washerwoman"	19½	21	19½	21½	Coast Survey, 1851, '67.
	From abreast of East Washerwoman to "West Washerwoman"	18	19½	18	19¾	Do.
	From abreast of West Washerwoman to Key West entrance	22½	23¾	22½	24	Do.
	Through the Southwest Channel from Key West to Boca Grande Key	31½	32¾	31½	33	Do.
	Coffin's Patches: In entrance	19	20½	19	20¾	Coast Survey, 1854.
	Coffin's Patches: At the anchorage	18	19½	18	19¾	Do.
	Bahia Honda Harbor: In entrance	19	20½	19	20¾	Coast Survey, 1857.
	Bahia Honda Harbor: At the anchorage	17	18½	17	18¾	Do.
	In entrance to New-Found Harbor	7	8½	7	8½	Do.
	At anchorage in New-Found Harbor	19	20½	19	20½	Do.
	Pye's Harbor: In entrance	9	10½	9	10½	Coast Survey, 1856.
	Pye's Harbor: At the anchorage	8	9½	8	9½	Do.
KEY WEST HARBOR	Through the East Channel to Whitehead's Point	28	29½	28	29½	Coast Survey, 1851, '52
	Through the Main Ship Channel to Whitehead's Point	27	28½	27	28½	Do.
	Through Rock Key Channel to Whitehead's Point	19½	20¾	19½	21	Do.
	Through Sand Key Channel to Whitehead's Point	27	28½	27	28½	Do.
	Through the Southwest Channel to Whitehead's Point	30	31½	30	31½	Do.
	Through the West Channel to Whitehead's Point	27	28½	27	28½	Do.

* Shifting sand-bar.

Table of depths, Atlantic Coast—Continued.

FLORIDA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
KEY WEST HARBOR—Continued.	From abreast of Whitehead's Point to Key West City	22½	23¾	22½	24	Coast Survey, 1851–'52.
	At the anchorage off Lazaretto	30	31¼	30	31½	Do.
	At the anchorage in Man-o'-war Harbor	24	25¼	24	25½	Do.
	At the anchorage near Northwest Passage Light-house	20	21¼	20	21½	Do.
	Through the Northwest Passage to abreast of the Light-house	17	18¼	17	18½	Coast Survey, 1873.
	Through the Northwest Passage to the Gulf of Mexico	12	13¼	12	13½	Do.
Tortugas Harbor	Through the Southeast Channel	45	46¼	45	46½	Coast Survey, 1867–'75.
	Through the Southwest Channel to Bird Key Harbor	19	20¼	19	20½	Do.
	Through the Northwest Channel to Bird Key Harbor	42	43¼	42	43½	Do.
	At the anchorage in North Key Harbor	33	34¼	33	34½	Coast Survey, 1875.
	In the entrance to Bird Key Harbor, east of Fort Jefferson	22½	23¾	22½	24	Coast Survey, 1873.
	In the entrance to Bird Key Harbor, west of Fort Jefferson	36	37¼	36	37½	Do.
	At the anchorage in Bird Key Harbor	30	31¼	30	31¾	Do.

GULF COAST.

FLORIDA.

Places.	Limits between which depths are given.	Mean low water.	Mean high water.	Spring low water.	Spring high water.	Authorities.
San Carlos Bay (Caloosa Entrance).	From the entrance up to Punta Rasa	7	8¾	6¾	8¾	Coast Survey, 1866–'67.
	At the anchorage under Sanibel Island	21	22¾	20¾	22¾	Do.
	At the anchorage off Punta Rasa	21	22¾	20¾	22¾	Do.
	To abreast of Middle Point	13	14¾	12¾	14¾	Do.
	Up the Bay to abreast of Sword Point	7	8¾	6¾	8¾	Do.
	Through to Matanzas Pass	11	12¾	10¾	12¾	Do.
	From Punta Rasa to mouth of Caloosa River	6½	8¼	6¼	8¼	Do.
Charlotte Harbor	Entrance through Boca Grande	18¼	19½	18	19½	Coast Survey, 1863.
	At the anchorage inside	16	17	15¾	17½	Do.
	Through to Punta Blanco	7	8	6¾	8½	Do.
	At anchorage under Gasparilla Island	27	28	26¾	28½	Do.
TAMPA BAY	Through Passage Key Inlet*	10	11½	9¾	12½	Coast Survey, 1875.
	Through Southwest Channel	16	17½	15¾	18½	Do.
	Through North Channel	21	22½	20¾	23½	Do.
	Through Pass à Grille to Boca Ceiga Bay	7	8½	6¾	9½	Coast Survey, 1873–'75.
	At anchorage under Mullet Key	21	22½	20¾	23½	Do.
	At anchorage under Western Shore of Egmont Key	9	10½	8¾	11½	Do.
	At anchorage under Northern Shore of Anna Maria or Palm Key	10	11½	9¾	12½	Do.
	Up the Bay to Point Pinelos	21	22½	20¾	23½	Do.
	At anchorage in Boca Ceiga Bay	19	20½	18¾	21½	Do.
	Through Boca Ceiga Bay to Tampa Bay	6½	8	5¾	9	Do.
	Through Sarasota Pass to Palmasola Bay	3½	5	3¼	6	Coast Survey, 1875.
	At the anchorage in Palmasola Bay	9	10½	8¾	11½	Do.
	Up Manatee River to abreast of Palmetto Landing	8	9½	7¾	10½	Coast Survey, 1873.
	At the Landing	5½	7	5½	8	Do.
	Up Manatee River to abreast of Manatee Landing	5½	7	5½	8	Do.
	At the Landing	5½	7	5½	8	Do.

* Shifting bar.

Table of depths, Gulf Coast—Continued.

FLORIDA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
TAMPA BAY—Continued	Entrance to Terraceia Bay	4½	6	4¼	7	Coast Survey, 1875.
	At anchorage in Terraceia Bay	8	9½	7¾	10½	Do.
	Up the Bay to its junction with Old Tampa and Hillsboro Bays	19	20½	18¾	21½	Coast Survey, 1876.
	Through Hillsboro Bay and up to Tampa wharves (Hillsboro River)	5	6½	4¾	7½	Do.
	Up Old Tampa Bay to its head at De Soto Bayou	7½	9	6¾	10	Coast Survey, 1875.
Boca Ceiga Bay	Entrance from Tampa Bay	6½	8	5¾	9	Coast Survey, 1873.
	Entrance through Pass à Grille	7	8½	6¾	9½	Do.
	Through Blind Pass to the Bay	2	3½	1¾	4½	Do.
	Passage through John's Pass	6½	8	6¼	9	Do.
	Entrance by Indian Pass	½	2	¼	3	Do
	Passage through The Narrows to Clearwater Harbor	½	2	¼	3	Do.
Clearwater Harbor	Entrance through Little Pass	4½	6	3½	8	Do.
	Over Inner Flats	3	4½	2¾	5½	Do.
	Through the harbor to The Narrows	½	2	¼	3	Do.
	Through the harbor to Big Pass Channel	3	4½	2¾	5½	Do.
	Entrance through Big Pass	8	9½	7¾	10½	Do.
	Up the harbor to Clearwater Bluff	5	6½	4¾	7½	Do.
	At the anchorage below Little Pass	6½	8	6¼	9	Do.
Wacassassa Bay	Channel into the harbor	6	8½	5¾	8¾	Coast Survey, 1856-'57
	At the anchorage in Waccasassa Harbor	9	11	8¾	11¼	Do.
	Up the Bay to Grassy Point	3	5½	2¾	5¾	Do.
	Through to Oyster Bay	4	6½	3¾	6¾	Do.
CEDAR KEYS	Sea-Horse Key Channel to Railroad Wharf	9	11½	8¾	11¾	Coast Survey, 1860, '71.
	Through North Key Channel to Railroad Wharf	5½	8	5¼	8½	Do.
	Through Northwest Channel to Railroad Wharf	6	8½	5¾	8¾	Do.
	At the anchorage between Depot Key and Railroad Wharf	16	18½	15¾	18¾	Do.
	In Steinhatchie River	3	5½	2¾	5¾	Coast Survey, 1875.
Ocilla River	In the entrance	3½	6	3¼	6½	Do.
Apalachee Bay	Through the Bay to mouth of Saint Mark's River	9	11½	8¾	11¾	Coast Survey, 1876.
	Across the Bay to mouth of Ocklockonee Bay	6¼	8¾	6	9	Do.
	At the anchorage off Shell Point	13	15½	12¾	15¾	Do.
	Entrance to Saint Mark's River over the "Devil's Elbow"	6½	8¾	6¼	9¼	Coast Survey, 1875.
	Up Saint Mark's River to the village of Saint Mark's	7	9¼	6¾	8¾	Do.
	Up the river from Devil's Elbow to Hunting Bayou	12½	14¾	12¼	15¼	Do.
	At the anchorage below the Devil's Elbow	12	14¼	11¾	14¾	Do.
	Entrance to East River	8	10¼	7¾	10¾	Do.
	Up East River to Denham's Bayou	1	3¼	¾	3¾	Do.
	Entrance from Apalachee Bay to Oyster Bay, by the East Channel	6½	8¾	6¼	9¼	Coast Survey, 1876.
	Entrance to same bay by West Channel	6½	8¾	6¼	9¼	Do.
	At the anchorage off Piney Island	11	13¼	10¾	13¾	Do.
	Passage between Piney and Porter's Islands into Dickson's Bay	1	3¼	¾	3¾	Do.
	At anchorage in Dickson's Bay	7	9¼	6¾	9¾	Do.
	From Dickson's Bay to entrance to King's Bay	3	5¼	2¾	5¾	Do.
	At anchorage in King's Bay	6	8¼	5¾	8¾	Do.
	From Apalachee Bay to entrance to Ocklockonee Bay	6¼	8¾	6	9	Do.
	At the anchorage between Upper and Lower Bars	9	11¼	8¾	11¾	Do.
	Over the Upper Bar	4	6	3¾	7	Do.
	Through the Bay to Ocklockonee River	7	9	6¾	10	Do.

Table of depths, Gulf Coast—Continued.

FLORIDA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Apalachee Bay—Continued	Up Ocklockonee River to northern end of Thom's Island	11	13	10¾	14	Coast Survey, 1876.
Saint George's Sound	Entrance to the Sound by Dog Island Channel	13	14⅓	12¾	14¾	Coast Survey, 1872.
	At the anchorage in Pilot's Cove	21	22⅓	20¾	22¾	Do.
	Entrance to the Sound through East Pass	15½	16¾	15¼	17¼	Coast Survey, 1858.
	At anchorage under Saint George's Island	15	16¼	14¾	16¾	Do.
	At anchorage between the west end of Dog Island and Crooked River	19	20⅓	18¾	20¾	Do.
	Over the Bar and in the entrance to Crooked River by the East Channel	4	5⅓	3¾	5¾	Do.
	Into Crooked River by the West Channel	3	4⅓	2¾	4¾	Do.
	Through Crooked River to Ocklockonee River	2	3⅓	1¾	3¾	Coast Survey, 1878.
	Through the Sound from Dog Island Channel to East Pass	15	16⅓	14¾	16¾	Coast Survey, 1858, '71.
	Through the Sound from abreast of East Pass to "The Bulkhead"	7	8⅓	6¾	8¾	Do.
	Over the Bulkhead to Apalachicola Bay	6	7⅓	5¾	7¾	Coast Survey, 1871.
	At anchorage in "The Gap" (Saint George's Island)	11	12⅓	10¾	12¾	Coast Survey, 1858.
	In entrance to Alligator Harbor	7	8⅓	6¾	8¾	Coast Survey, 1871.
	Over Inside Flats	5	6⅓	4¾	6¾	Do.
	At the anchorage	6½	7¾	6⅓	8⅓	Do.
APALACHICOLA BAY	Entrance over Bulkhead from Saint George's Sound	6	7⅓	5¾	7¾	Do.
	Through New Inlet* to the Bay	7	8	6¾	8¾	Coast Survey, 1873.
	Entrance, through Sand Island Pass	1	2	¾	2¾	Coast Survey, 1860.
	Main entrance, through West Pass*	15	15¾	15	15¾	Coast Survey, 1875.
	At lower anchorage under Saint George's Island	18	18¾	18	18¾	Coast Survey, 1856.
	Through the Bay from the Bulkhead to entrance to Saint Vincent's Sound	7	7¾	7	7¾	Do.
	In entrance to Saint Vincent's Sound	5	5¾	5	5¾	Do.
	From the Bulkhead to East Bay	5	5¾	5	5¾	Coast Survey, 1860.
	Across the Bay from the Bulkhead to Apalachicola entrance	7	7¾	7	7¾	Coast Survey, 1856.
	At upper anchorage	10	10¾	10	10¾	Do.
	From West Pass to East Bay	6	6¾	6	6¾	Coast Survey, 1860.
	Up East Bay to its head	5	5¾	5	5¾	Do.
	From West Pass to Apalachicola entrance	7	7¾	7	7¾	Coast Survey, 1856–'60.
	Up Apalachicola River to the Town Wharves by the Straight Channel	4	4¾	4	4¾	Do.
	Up Apalachicola River to Town Wharves by Crooked Channel	4	4¾	4	4¾	Do.
Saint Vincent's Sound	Entrance from Apalachicola Bay	5	5¾	....	....	Coast Survey, 1874.
	Entrance through Indian Pass†	7	7¾	....	....	Coast Survey, 1874–'75.
	Through the Sound from Apalachicola Bay to Indian Pass	4	4¾	....	....	Coast Survey, 1875.
	At eastern anchorage abreast of Saint Vincent's Point	8	8¾	....	....	Coast Survey, 1874.
	At western anchorage under North Shore of Saint Vincent's Island, near Indian Pass	9	9¾	....	....	Do.
Saint Joseph's Bay	In the entrance	19	20⅓	18¾	20½	Coast Survey, 1875.
	Up the Bay to abreast of Saint Joseph's	28	29½	27¾	29½	Do.
	At the anchorage off Saint Joseph's	28	29½	27¾	29½	Do.
	At the anchorage in Eagle Harbor	21	22⅓	20¾	22½	Do.
Saint Andrew's Sound	Entrance by Main Ship Channel†‡	6½	8	6⅓	8¼	Coast Survey, 1877.
	Entrance by Beach Channel	8	9½	7¾	9¾	Do.
	Over Inner Bar	8	9½	7¾	9¾	Do.
	At anchorage under North Shore of Crooked Island	19	20⅓	18¾	20⅓	Do.

* Shifting bar. † Shifting channel. ‡ This is the only channel buoyed.

Table of depths, Gulf Coast—Continued.

FLORIDA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Saint Andrew's Sound-Continued.	At upper anchorage near head of the Sound	19	20⅛	18¾	20⅜	Coast Survey, 1877.
	At anchorage under North Shore of Hurricane Island (Passage leading to Saint Andrew's Bay)	19½	21	19¼	21¼	Do.
	Up Saint Andrew's Sound to mouth of Wild Goose Lagoon	6	7⅛	5¾	7⅜	Do.
	Passage to Saint Andrew's Bay	10	11⅛	9¾	11⅜	Do.
Saint Andrew's Bay	Over Bar*	17	18⅛	16¾	18⅜	Do.
	Across Inner Bar (abreast of Hurricane Island)	16	17⅛	15¾	17⅜	Do.
	At the anchorage off Davis' Point	21	22⅛	20¾	22⅜	Do.
	At the anchorage off Courtney's Point	24	25⅛	23¾	25⅜	Do.
	From the Bar through the North Channel	10	11⅛	9¾	11⅜	Do.
	Up the Bay to Red-fish Point (entrance to East Bay)	20	21⅛	19¾	21⅜	Do.
	Up East Bay from entrance to East Point	21	22⅛	20¾	22⅜	Coast Survey, 1876-'77.
	From abreast of East Point to Last Point	13½	15	12¾	15¾	Do.
	From abreast of Last Point to Harrison's Bayou	6½	7½	5	8	Do.
	From abreast of Last Point to Wetappo River	3	4⅛	2¾	4⅜	Do.
	Through the bay from Davis' Point to Dyer's Point (junction with North and West Bays)	22½	24	22¼	24¼	Do.
	From Dyer's Point to North Bay Point	25½	27	25¼	27¼	Do.
	Up North Bay to Bull Point	12½	14	12¼	14¼	Do.
	From abreast of Bull Point to Williams' Bayou	6½	8	6¼	8¼	Do.
	From abreast of Williams' Bayou to Head of the Bay	4	5⅛	3¾	5⅜	Do.
	In the entrance to West Bay	24	23⅛	23¾	25⅜	Do.
	Up West Bay from middle of entrance to Crane Point	13	14⅛	12¾	14⅜	Do.
	From abreast of Crane Point to Head of the Bay	6½	8	6¼	8¼	Do.
	In entrance to Burnt Mill Creek	10	11⅛	9¾	11⅜	Do.
	At the anchorage in Burnt Mill Creek	7	8⅛	6¾	8⅜	Do.
	In entrance to West Bay Creek	6½	7½	6	8	Do.
	At anchorage off Crane Point	13	14⅛	12¾	14⅜	Do.
	At anchorage in South Bight at Head of Bay	10	11⅛	9¾	11⅜	Do.
CHOCTAWHATCHEE BAY and tributaries.	In entrance through East Pass*	7½	8½	7	9	Coast Survey, 1871.
	Through The Narrows	5	6	4½	6½	Do.
	At the anchorage between Cobb's Point and Black Point	33	34	32½	34½	Do.
	Up the bay from Cobb's Point to Four-Mile Point	22½	23½	22	24	Do.
	From abreast of Four-Mile Point to Western Head of the Bay	9	10	8½	10½	Do.
	From East Pass to West End of bay at Five-Mile Bayou	6	7	5½	7½	Coast Survey, 1872
	Up Five Mile Bayou to its Head	13	14	12½	14½	Coast Survey, 1871
	At anchorage in Bayou	25½	26½	25½	27	Do.
	Up Garnier's Bayou to its Head	8	9	7½	9½	Do.
	Up Garnier's Bayou to Little Bayou	24	25	23½	25½	Do.
	Up Garnier's Bayou to Nigger Bayou	22½	23½	22½	24	Do.
	In Little Bayou to its Head	7	8	6½	8½	Do.
	In Don's Bayou to its Head	9	10	8½	10½	Do.
	At the anchorage in Garnier's Bayou	25½	26½	25½	27	Do.
	At the anchorage in Cummings' Cove	21	22	20½	22½	Do.
	In the entrance to Joe's Bayou	3	4	2½	4½	Coast Survey, 1872.
	At the anchorage in Joe's Bayou	13	14	12½	14½	Do.
	In Boggy Bayou, at the anchorage	18	19	17½	19½	Do.
	To Head of Bayou	6	7	5½	7½	Do.
	Rocky Bayou to its Head	6	7	5½	7½	Do.
	At the anchorage in Bayou	19½	20½	19	21	Do.

* Shifting channel.

Table of depths, Gulf Coast—Continued.

FLORIDA AND ALABAMA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
CHOCTAWHATCHEE BAY and tributaries—Continued.	Hogtown Bayou to its Head	6	7	5¾	7½	Coast Survey, 1872.
	At anchorage in Bayou	11	12	10¾	12½	Do.
	At entrance to Bayou	16½	17½	16	18	Do.
	Entrance to "The Basin"	3	4	2¾	4½	Do.
	Anchorage in "The Basin"	6	7	5½	7½	Do.
	Alaqua Bayou to its Head	5	6	4½	6½	Do.
	Entrance to Bayou	5	6	4½	6½	Do.
	La Grange Bayou to its Head	3	4	2¾	4½	Do.
	At entrance to Bayou	8½	9½	8¼	10	Do.
	Into Four-Mile Creek	5	6	4¾	6¼	Do.
	Up Four-Mile Creek to "The Divide"	9	10	8¾	10½	Do.
	Jolly Bay to its Head	4	5	3½	5½	Do.
	At entrance to Bay	7½	8½	7	9	Do.
	Black Creek: at the entrance	6	7	5½	7½	Do.
	Up the creek to Mouth of Mitchell's River	9	10	8½	10½	Do.
	Black Creek to Russian Cut-off	8½	9½	8	10	Do.
	For One-and-a-half Miles above the Cut-off	10	11	9½	11½	Do.
	At the entrance to Mitchell's River	9	10	8½	10½	Do.
	Up the River to Russian Cut-off	11	12	10½	12½	Do.
	From Russian Cut-off to Live-Oak Cut-off	10	11	9¾	11½	Do.
	Through Russian Cut-off to Black Creek	9	10	8¾	10½	Do.
	Through Live Oak Cut-off to Choctawhatchee River	7	8	6¾	8½	Do.
	From Live-Oak Cut-off to junction of Mitchell's River with the Choctawhatchee	9	10	8¾	10½	Do.
	Entrance to Nancy's Gut	2½	3½	2	4	Do.
	Through the Gut to Mitchell's River	7½	8½	7	9	Do.
	Entrance to Indian River	3½	4½	3	5	Do.
	To junction of Indian River with Jones' Creek	9	10	8¾	10½	Do.
	To junction of Indian River with Choctawhatchee River	9½	10½	9¼	11	Do.
	Up Jones' Creek to its Head	10	11	9¾	11½	Do.
	Entrance to Cypress-Top River	4	5	3½	5½	Do.
	Through the River to Indian River	6	7	5½	7½	Do.
	Entrance to Choctawhatchee River through Straight River of the Delta	3	4	2½	4½	Do.
	Entrance to same River through Middle River of the Delta	3	4	2½	4½	Do.
	Entrance to same River through First River of the Delta	2½	3½	2	4	Do.
	Up Choctawhatchee River to junction with Indian River	11	12	10¾	12½	Do.
	From Indian River to Live-Oak Cut-off	14½	15½	14¼	16	Do.
	From Live-Oak Cut-off to junction with Mitchell's River	15	16	14¾	16½	Do.
	Peach Creek, entrance to	6½	7½	6	8	Do.
	Up the Creek to Tucker's Bayou	7	8	6½	8½	Do.
Santa Rosa Sound	Entrance by Main Channel (Pensacola Bay)	19	20	18½	20½	Coast Survey, 1856.
	Entrance by Narrows from Choctawhatchee Bay	5	6	4½	6½	Coast Survey, 1871.
	From Pensacola entrance to Deer Point	19	20	18½	20½	Coast Survey, 1856.
	From Deer Point to Two Points	17	18	16½	18½	Coast Survey, 1871.
	From Two Points to Manatee Point (entrance to Narrows)	6	7	5½	7½	Do.
	From abreast of Deer Point to Pensacola Wharves	8	9	7¾	9½	Coast Survey, 1860.
	At the anchorage in Fishing Bend	16	17	15¾	17½	Coast Survey, 1856

Table of depths, Gulf Coast—Continued.

FLORIDA, ALABAMA, AND MISSISSIPPI.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
PENSACOLA BAY and tributaries.	Entrance by Main Channel	19½	20⅓	19¼	21	Coast Survey, 1856.
	From entrance to Deer Point	19	20	18¾	20⅓	Do.
	Up to anchorage off Warrington Navy-yard	30	31	29¾	31¼	Coast Survey, 1860.
	At anchorage off the Navy-yard	33	34	32¾	34½	Do.
	Up the Bay to Pensacola	30	31	29¾	31¼	Do.
	At anchorage off Pensacola	22½	23½	22	24	Do.
	Up the Bay to entrance to East Bay	19½	20¾	18¾	21¼	Do.
	Through East Bay to Escribano Point (entrance to Blackwater Bay)	8½	9¾	7¾	10¼	Do.
	Up Pensacola Bay to entrance to Escambia Bay	18	19⅓	17⅓	19¾	Do.
	Through Escambia Bay to Live-Oak Point	7½	8¾	6¾	9¼	Do.
	At anchorage off Devil's Point	9	10⅓	8⅓	10¾	Do.
	At anchorage in Old Navy Cove (Pensacola Bay)	15	16	14½	16½	Do.
Perdido River (Boundary line)	Over Bar*	6½	8¾	6	9¼	Coast Survey, 1867.
	At the anchorage	9	11¼	8½	11¾	Do.
MOBILE BAY	Over Bar by Main Ship Channel	19½	20½	19¼	20¾	Coast Survey, 1847-'52.
	Over Bar* by the Swash Channel	6½	7½	6¼	7¾	Coast Survey, 1847-'48.
	Over Bar* through "The Gut"	6	7	5¾	7¼	Do.
	Over Little Pelican Channel Bar* to Sand Island Channel	11	12	10¾	12¼	Do.
	Through Sand Island Channel to Main Ship Channel	12¼	13¼	12	13½	Do.
	Over Bar* by Middle Channel into Pelican Bay	12¼	13¼	12	13½	Do.
	From Pelican Bay to Main Channel of Mobile Bay	8½	9½	8¼	9¾	Do.
	Over Bar,* by Pelican Channel, into Pelican Bay	14	15	13¾	15¼	Do.
	At anchorage in Pelican Bay	18	19	17¾	19¾	Do.
	From Pelican Bay across Dauphine Shoals to Main Ship Channel	8½	9½	8¼	9¾	Do.
	From Pelican Bay across Pelican Island Shoals to Sand Island Channel	12	13	11¾	13¼	Do.
	From inside Mobile Bar to Grant's Pass (entrance to Mississippi Sound)	9	10⅓	8¼	11	Do.
	From inside the Bar to anchorage at The Lower Fleet	19½	20½	19¼	20¾	Do.
	From The Lower Fleet to abreast of Mullet Point	12½	13½	12¼	13¾	Do.
	From abreast of Mullet Point to anchorage at The Upper Fleet	12½	13½	12¼	13¾	Do.
	From The Upper Fleet to the city of Mobile	8	9	7¾	9¼	Do.
	Through the new Dredged Channel,† from The Lower Fleet to Choctaw Point	18	19	17¾	19¼	U. S. Engineers, 1883.
	After crossing Dog River Bar to Mobile wharves	12	13	11¾	13¼	Coast Survey, 1860.
	At the anchorage in Navy Cove under north shore of Mobile Point	13	14	12¾	14¼	Coast Survey, 1847-'48.
	Entrance to Bon Secours Bay	12	13	11¾	13¼	Coast Survey, 1851.
	At anchorage in Bon Secours Bay	9½	10½	9¼	10¾	Do.
	Entrance to Fish River	4½	5¼	4	5½	Do.
	At anchorage in Fish River	8½	9⅓	8¼	9¾	Coast Survey, 1848-'50
	At anchorage in Weeks' Bay	3½	4½	3¼	4¾	Do.
	In entrance to Dog River	3½	4½	3¼	4¾	Do.
	Over Bar into Blakely River	5	6	4¾	6¼	Coast Survey, 1860.
	Up Blakely River to junction with Apalachee River	11⅓	12½	11¼	12¾	Do.
	Passage to Minetta Bay	7	8	6¾	8¼	Do.
	Anchorage in Minetta Bay	7½	8½	7¼	8¾	Do.

* Shifting sand-bar. † Channel in process of construction January, 1883.

NOTE.—From Pensacola westward, on the Gulf coast, there is generally but one tide in a day—that due to the moon's declination. The tides are much affected by the winds.

Table of depths, Gulf Coast—Continued.

ALABAMA AND MISSISSIPPI.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
MOBILE BAY—Continued	Over Bar into Apalachee River by East Channel	4½	5½	4¼	5¾	Coast Survey, 1850.
	Over Bar into Apalachee River by West Channel	4⅝	5⅝	4½	5¾	Do.
	Up the River to junction with Blakely River	12	13	11¾	13¼	Do.
	From Blakely River to junction with Tensaw River	19½	20½	19¼	20¾	Do.
	Channel into Big Batteau Bay	6¼	7¼	6	7½	Do.
	Channel into Chacaloochee Bay	4¼	5¼	4	5½	Do.
	Entrance to Tensaw River from Mobile Bay	11¼	12¼	11	12½	Do.
	Up Tensaw River to junction with Apalachee River	13	14	12¾	14¼	Do.
	Entrance to Spanish River from Mobile Bay	12¼	13¼	12	13½	Coast Survey, 1860.
	Up Spanish River to Grand Bay	7	8	6¾	8¼	Do.
	Up Spanish River to entrance to Raft River	16	17	15¾	17¼	Do.
	Up Spanish River to junction with Alabama River	16	17	15¾	17¼	Do.
	In Levan's Bay	2¾	3¾	2½	4	Do.
	In Blind Bay	1¾	2¾	1½	3	Do.
	In Grand Bay	4½	5½	4¼	5¾	Do.
	Up Mobile River to Alabama River	13	14	12¾	14¼	Do.
MISSISSIPPI SOUND*	Through Grant's Pass from Mobile Bay	5¼	6¾	4½	7½	Coast Survey, 1848–'49.
	Through Pass aux Huitres from Mobile Bay	1½	3	¾	3½	Do.
	Through Horn Island Pass	16	17½	15¼	18	Coast Survey, 1852–'53.
	Through Dauphine Island Pass†	8¾	10¼	8	10¾	Do.
	Passage between Ship Island† and Horn Island	13	14½	12¼	15	Do.
	Through Main Channel over Ship Island Bar	21	22½	20½	23	Coast Survey, 1848.
	Through East Channel over Ship Island Bar	18	19½	17½	20	Do.
	Through South Channel over Ship Island Bar	21	22½	20½	23	Do.
	At the anchorage	21	22½	20½	23	Do.
	Over Cat Island Bar	16	17½	15½	18	Do.
	Through Cat Island Channel to South Pass	15	16½	14½	17	Do.
	At the anchorage off South Spit of Cat Island	21	22½	20½	23	Do.
	From Grant's Pass through the Sound to abreast					Do.
	of Isle aux Herbes	7½	9	6¾	9½	Coast Survey, 1848–'49.
	From abreast Isle aux Herbes to Horn Island Pass	13	14½	12¼	15¼	Coast Survey, 1852–'53
	At the anchorage inside of Horn Island	19	20½	18¼	21	Do.
	From Horn Island Pass to abreast of Round Island	14	15½	13¼	16	Do.
	Through the Sound from abreast of Round Island to Cat Island	11	12½	10¼	13	Coast Survey, 1848.
	From abreast of Cat Island to Pass Marianne	8	9½	7½	10	Do.
	Through Pass Marianne	10	11½	9½	12	Do.
	From Pass Marianne to Saint Joseph's Island	8	9½	7½	10	Do.
	In Grand Island Pass to Lake Borgne	21	22½	20½	23	Do.
	Passage from Mississippi Sound to Grand Bay	7	8½	6¼	9	Do.
	At anchorage in Bay	7	8½	6¼	9	Do.
	Channel into Point aux Chênes Bay	7½	9	6¾	9½	Do.
	At anchorage in Bay	6½	8	5¾	8½	Do.
	From Grand Batture Island Shoal to East Pascagoula Wharf	7½	9	6¾	9½	Coast Survey, 1852–'53
	Into Pascagoula River	5	6½	4¼	7	Do.
	Up Pascagoula River to Krebs' Lake	5	6½	4¼	7	Do.
	From off Round Island to mouth of West Pascagoula River	1½	3	¾	3½	Do.
	From off Round Island to entrance to Biloxi Bay	7	8½	6¼	9	Coast Survey, 1855.
	Over Biloxi Bar:					
	East Channel	6	7½	5¼	8	Do.
	West Channel	4	5½	3¼	6	Do.
	At the anchorage under Deer Island	8	9½	7¼	10	Do.

* Rise and fall of tides is greatest when the moon's declination is greatest, either north or south.

† Not buoyed.

Table of depths, Gulf Coast—Continued.

MISSISSIPPI AND LOUISIANA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
MISSISSIPPI SOUND*	Up the Bay to Biloxi Wharves	3	4½	2½	5	Coast Survey, 1855.
	At the wharves	7–11	8½–12½	6½–10½	9–13	Do.
	Up the Bay to Barnard's Island	4	5½	3½	6	Do.
	From Mississippi Sound to Biloxi	4	5½	3½	6	Do.
	Through Biloxi Bay to Fort Point	3	4½	2½	5	Do.
	Abreast of Campbell's Brick-Yard, above Ship-Yard Point	19¼	21	18¾	21¼	Do.
	At anchorage in Man-o'-war Harbor †	18¼	20	17¾	20¼	Coast Survey, 1848.
	Passage through Raccoon Swash (between Raccoon Spit and Spade-fish Shoal) ‡	7	8¾	6½	9	Do.
	From the Black Buoy off Spade-fish Shoal to abreast of Mississippi City	7	8¾	6½	9	Do.
	At Mississippi City Wharves	1–5	2¾–6¾	½–4½	3–7	Do.
	At Pass Christian Wharves	1–11	2¾–12¾	½–10½	3–13	Do.
	Through Pass Christian to Bay of Saint Louis	6½	7¾	6	8½	Do.
	Bay of Saint Louis to Delectable Point	7	8¾	6½	9	Do.
	From Delectable Point to Head of the Bay	4	5¾	3½	6	Do.
	Into Cat Island Harbor over Bar ‡	16	17¾	15½	18	Do.
	At the anchorage in Cat Island Harbor † north of South Shell-bank Flats	22	23¾	21½	24	Do
	At anchorage in Cat Island Channel near East Buoy	33	34¾	32½	35	Do.
	At anchorage in Spit Cove	6	7¾	5½	8	Do.
	Through Shell-bank Channel	15	16¾	14½	17	Do.
	Through South Pass and up to Grand Island Pass	8	9¾	7½	10	Do.
	In anchorage behind Saint Joseph's Island	8	9¾	7½	10	Do.
Chandeleur Sound	Passage† through to Isle au Breton Sound	11	12¾	10½	13	Coast Survey, 1854, '73.
	At anchorage abreast of Freemason's Islands	12	13¾	11½	14	Coast Survey, 1873.
Breton Sound	Passage† through to Mississippi Delta	10	11¾	9½	12	Do.
	At anchorage west of Grand Gosier Islands	14	15¾	13½	16	Coast Survey, 1869.
	At anchorage between Grand Gosier Islands and Breton Island	24	25¾	23½	26	Do.
Bird Island Sound	At the anchorage †	7	8	6½	8½	Do.
Bay Rondo	At the anchorage† §	12	13	11½	13½	Do.
Bland Bay	At the anchorage †	6	7	5½	7½	Do.
Garden Island Bay	At the anchorage †	9	10	8½	10½	Coast Survey, 1868.
East Bay	At the anchorage †	6	7	5½	7½	Do.
West Bay	At the anchorage †	16	17	15½	17½	Do.
LAKE BORGNE	Passage† through Grand Island Pass	24	25¾	23½	26	Coast Survey, 1870.
	At anchorage in the Lake	8½	9¾	8	10¼	Do.
	At anchorage† in West Lake, between Alligator and Proctor Points	7	8¼	6½	9	Do.
	At anchorage† in South Lake, between Proctor Point and Point aux Marchettes	6½	7¾	6	8¼	Do.
	At anchorage† in Heron Bay (North Shore)	3	4½	2½	5	Do.
	From Grand Island Pass to Mouth of Pearl River	7½	8¾	7	9¼	Do.
	Up Pearl River† to Little Lake Pass	18	19½	17½	20	Do.
	Through Little Lake Pass	12	13½	11½	14	Do.
	At the anchorage in Little Lake	4	5½	3½	6	Coast Survey, 1870.
	Through Little Lake to North Pass of West Pearl River	8½	9¾	8	10¼	Do.
	Through North Pass to East Mouth	12½	13¾	12	14¼	Do.
	Through East Mouth to junction with West Mouth	18	19½	17½	20	Do.
	From Little Lake through East Pass to The Rigolets	9½	10¾	9	11¼	Do.

* Rise and fall of tides is greatest when the moon's declination is greatest, either north or south.

† Tides much influenced by the winds.

‡ Shifting bar.

§ Dangerous in northerly and northwesterly winds.

Table of depths, Gulf Coast—Continued.

MISSISSIPPI AND LOUISIANA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Least water in channel. Mean. High water.	Least water in channel. Spring tides. Low water.	Least water in channel. Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
LAKE BORGNE	Through West Mouth of West Pearl River to junction with East Mouth	8	9½	7½	10	Coast Survey, 1870.
	Through The Rigolets to Lake Pontchartrain	28½	29¾	28	30½	Do.
	Through the Little Rigolets from Lake Borgne to The Rigolets	6	7½	5½	8½	Do.
	Through Saint Catherine's Pass to Lake Saint Catherine	8½	9¾	8	10½	Do.
	Through Chef Menteur Pass from East Lake Borgne to Lake Pontchartrain	4	5½	3½	6	Do.
	In Chef Menteur Pass	28	29½	27½	30	Do.
	Through Le Petit Pass from Mississippi Sound to Lake Borgne	7	8½	6½	9	Do.
	Anchorage under Malheureux Point	7½	8¾	7	9½	Do.
	From The Rigolets through Fort Pike Channel into Lake Saint Catherine	6½	7¾	6	8½	Do.
	Anchorage in Lake Saint Catherine	4½	5¾	4	6½	Do.
LAKE PONTCHARTRAIN *	From the western end of The Rigolets to Point aux Herbes	5½	No tides.			Coast Survey, 1870–71.
	From abreast of Point aux Herbes to anchorage off Lake End (Milneburg)	9½	......	......	......	Do.
	At the anchorage under Breakwater off Milneburg	12	......	......	......	Do.
	From off Lake End to Bayou Saint John	11	......	......	......	Do.
	At entrance to Bayou	8	......	......	......	Do.
	From off Bayou Saint John Light-house to New Canal	11	......	......	......	Do.
	At entrance to New Canal	6½	......	......	......	Do.
	At entrance to Bayou Bonfuca	4	......	......	......	Do.
	At anchorage off Bayou Bonfuca	8	......	......	......	Do.
	At anchorage between Point Platte and Ragged Point	8	......	......	......	Do.
	Deepest Water in Lake between Rigolets and Bayou Tchoupitoulas ‡	16	......	......	......	Do.
MISSISSIPPI RIVER	Over Bar:					
	Through North Pass §	4	5	3½	5½	Coast Survey, 1860.
	Through Pass à L'Outre §	9	10	8½	10½	Coast Survey, 1867.
	Through Northeast Pass §	7½	8¾	7	9	Do.
	Through Southeast Pass §	6½	7½	6	8	Do.
	Through South Pass	30	31	29½	31½	Coast Survey, 1875.
	Through Southwest Pass ‖	15	16	14½	16½	Coast Survey, 1867.
	To Head of Passes:					
	North Pass to Pass à L'Outre	10	11	9½	11½	Coast Survey, 1860.
	Through Pass à L'Outre	19½	20½	19	21	Coast Survey, 1867.
	Through Northeast Pass	15	16	14½	16½	Do.
	Through Southeast Pass	9½	10½	9	11	Do.
	Through South Pass	27	28	26½	28½	Coast Survey, 1875.
	Through Southwest Pass	17½	18½	17	19	Coast Survey, 1867.
	From Head of the Passes to Fort Jackson †	33	No tides.			Coast Survey, 1871–'74.
	From The Forts to "Quarantine" †	72	......	......	......	Do.
	From Quarantine to Sixty-Mile Point †	78	......	......	......	Do.

* Tides governed altogether by winds and freshets.

† Depth of water influenced solely by the wind and by freshets and crevasses.

‡ No survey westward from this bayou.

§ Shifting bar.

‖ This bar had 18½ feet on it in 1871. Since the jetty system has been adopted, however, this entrance has been mostly abandoned and is gradually shoaling.

Table of depths, Gulf Coast—Continued.

LOUISIANA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
MISSISSIPPI RIVER—Continued.	From Sixty-Mile Point to Poverty Point*	60	No tides.			Coast Survey, 1871–'74.
	From Poverty Point to English Turn*	48	....	....	....	Do.
	From English Turn to New Orleans*	39	....	....	....	Do.
	From New Orleans to Twelve-Mile Point*	63	....	....	....	Coast Survey, 1875–'76.
	From Twelve-Mile Point to Hahnville*	68	....	....	....	Coast Survey, 1876.
	From Hahnville to Bonnet Carré Point*	48	....	....	....	Do.
	From Bonnet Carré Point to Willow Bend*	55	....	....	....	Coast Survey, 1876–'77.
	Through Willow Bend and Grand View Reach*	71	....	....	....	Coast Survey, 1876–'79.
	From west end of Grand View Reach to College Point*	54	....	....	....	Coast Survey, 1877.
	From College Point to Brilliant Point*	70	....	....	....	Do.
	From Brilliant Point to Point Houmas*	66	....	....	....	Do.
	Deepest water† in river from Head of Passes to Point Houmas‡	225	....	....	....	Coast Survey, 1876.
Barataria Bay	Over Bar§ by the East Channel	6½	7¾	6¼	8	Coast Survey, 1878.
	Over Bar§ by the South Channel	6½	7¾	6¼	8	Do.
	Through Grand Pass	28	29¼	27¾	29½	Do.
	Up the bay from Grand Pass to anchorage off Queen Bess' Island	12½	13½	12¼	14	Do.
	At the anchorage north of the Light-house	18½	19¾	18¼	20	Do.
	At the anchorage in Bayou Fifi	16	17¼	15¾	17½	Do.
	Through Bayou Fifi to Bay des Ilettes	2½	3¾	2¼	4	Do.
	Through Bayou Beauregard to Bay des Ilettes (by North Branch)	2½	3¾	2¼	4	Do.
	Through Bayou Beauregard to Bay des Ilettes (by South Branch)	2	3¼	1¾	3½	Do.
	At the anchorage in Bay des Ilettes	3½	4¾	3¼	5	Do.
	In the entrance to Champagne Bay from Barataria Bay	3	4¼	2¾	4½	Do.
	Through Champagne Bay to entrance to West Champagne Bay	1½	2¾	1¼	3	Do.
	In entrance to West Champagne Bay	6½	7¾	6¼	8	Do.
	Up Barataria Bay to abreast of Pelican Point	5	6¼	4¾	6½	Do.
Pass Fourchon	Over Bar	6½	8	6	8½	Coast Survey, 1854.
	At the anchorage	15	16½	14½	17	Do.
	Passage between Ship Island Shoal and Isle Dernier	24	25½	23¾	25¾	Coast Survey, 1853.
Caillou Bay	At the anchorage above Raccoon Point	9	10½	8¾	10¾	Do.
	In the entrance	6½	7½	6	8	Do.
ATCHAFALAYA BAY‖	From the Gulf to Southwest Reef Light-house	10	11½	9½	12	Coast Survey, 1858–'59
	From abreast of Light-house to Barrel Stake Buoy	10	11½	9½	12	Do.
	From Barrel Stake Buoy to Cut-off Channel Buoy	8	9¾	7¾	10	Do.
	From Cut-off Channel Buoy to "The Narrows"	6½	8¼	6¼	8½	Do.
	In "The Narrows"	7	8¾	6¾	9¼	Do.
	From "The Narrows" to mouth of Atchafalaya River	6½	8	6	8½	Do.
	Entrance to Atchafalaya River (mid-channel)	48	49½	47½	50	Do.
	At anchorage under Point au Fer Reef (between Grecian Shoal Beacon and Southeast Beacon)	7	8½	6½	9	Do.
	At anchorage off the mouth of Atchafalaya River	22	23¾	21¾	24	Do.
	Through the bay to entrance to Wax Lake	6	7¾	5¾	8	Do.

* No tides. Depth of water influenced solely by freshets and crevasses.
† About a mile below Hahnville.
‡ No hydrographic surveys completed above this point.
§ Shifting bar.
‖ Dangerous in west and southwest gales, and must not be attempted by a stranger without a pilot.

Table of depths, Gulf Coast—Continued.

LOUISIANA AND TEXAS.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
ATCHAFALAYA BAY*—Continued.	In the entrance to Wax Lake off west end of Belle Isle	27	28½	26¾	29	Coast Survey, 1858–'59.
	Through the Bay to entrance to East Bay†	5	6½	4¾	7	Do.
	Anchorage in East Bay	6½	8	6	8½	Do.
	From "The Narrows" to entrance to Shell Island Pass (Little Bay)	5½	7	5	7½	Do.
	At anchorage in Little Bay	13	14½	12¾	15	Do.
	From "The Narrows" through the South Bay to abreast of Fishing Point	4	5½	3¾	6	Do.
	Anchorage in the South Bay, between Turn Point and Point au Fer	5	6½	4¾	6	Do.
	Through the bay to Morrison's Cut-off	6½	8	6	8½	Do.
	In the Cut-off	8	9½	7¾	10	Do.
	From Morrison's Cut-off to entrance to Coto Blanche Bay	5	6½	4¾	7	Do.
	Passage between Bird Key and Rabbit Island	7	8½	6¾	9	Do.
	Channel to the westward of Bird Key, from Atchafalaya Bay to abreast of the Key	5	6½	4¾	7	Do.
	From abreast of Bird Key to Coto Blanche Bay	5	6½	4¾	7	Do.
	Channel from the Gulf close under west end of Marsh Island to Cote Blanche Bay	7	8½	6¾	9	Do.
	From Bird Key Channel to Salt Point	3½	5	3	5½	Do.
Vermilion Bay	Over Bar‡	8	9½	7¾	10	Coast Survey, 1856.
	At the anchorage inside the bar	27	28½	26¾	29	Do.
	At the anchorage nearly half a mile N. by E. of Old Light-tower on Marsh Island	39	40½	38¾	41	Do.
Calcasieu River	Over Bar‡	5	6½	4¾	7	Do.
	At anchorage abreast of Light-house	15	16½	14¾	17	Do.
Sabine Pass (Boundary)	In the entrance‡	7½	9	7	9½	Coast Survey, 1853.
	At the anchorage abreast of Light-house	15	16½	14¾	17	Do.
GALVESTON BAY and tributaries.	Over the Bar,‡ by channel of 1879	11	12	10¾	12¼	Coast Survey, 1879.
	Over the Bar,‡ by Fort Point Channel	8	9	7¾	9¼	Coast Survey, 1867.
	Over the Bar,‡ by Northeast Channel	9	10	8¾	10¼	Do.
	At the anchorage outside the Bar	42	43	41¾	43¼	Do.
	At the anchorage north of Pelican Spit	40	41	39¾	41¼	Do.
	At the anchorage west of southwest point of Bolivar Point	13	14	12¾	14¼	Do.
	From Quarantine Buoy to anchorage off the city	24	25	23¾	25¼	Do.
	From the light-vessel to "The Turn" abreast of "Turn Buoy"	23	24	22¾	24¼	Do.
	Across Fort Point Bar to Quarantine Buoy	18½	19½	18¼	19¾	Coast Survey, 1883.
	Through the Bolivar Channel§ from Turn Buoy to First Channel-buoy	36	37	35¾	37¼	Coast Survey, 1867.
	Through Dredged Channel§ to Red Fish Bar	9	10	8¾	10¼	U. S. Engineers, 1881.
	Over Red Fish Bar§	9	10	8¾	10¼	Do.
	Through Upper Bay to Turtle Bay	6½	7½	6¼	7¾	Coast Survey, 1855.
	At anchorage in Upper Bay off Turtle Bay Bar	9	10	8¾	10¼	Do.
	Over Bar into Turtle Bay	2¾	3¾	2½	4	Do.
	At anchorage in the bay	4	5	3¾	5¼	Do.
	Through Upper Bay to entrance to San Jacinto Bay Dredged Channel§ to Morgan's Point	9	10	8¾	10¼	U. S. Engineers, 1881.
	In entrance to San Jacinto Bay	18	19	17¾	19¼	Coast Survey, 1855.
	Across Hannah's Reef to East Bay	5½	6½	5¼	6¾	Coast Survey, 1854.
	At the anchorage off Elm Grove	7½	8½	7¼	8¾	Do.

* Dangerous in W. and SW. gales, and must not be attempted without a pilot.
† From the Narrows.
‡ Shifting sand-bar.
§ The United States Engineers expect to have this channel 100 feet wide and 12 feet deep by June 30, 1883.

Table of depths, Gulf Coast—Continued.

TEXAS.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
GALVESTON BAY and tributaries—Continued.	Up East Bay from Elm Grove to Marsh Point	6	7	5¾	7½	Coast Survey, 1854.
	From Marsh Point to Head of Bay	3	4	2¾	4½	Do.
	Through West Bay to Railroad Bridge	5	6	4¾	6½	Coast Survey, 1867.
	From Railroad Bridge to Caronkaway Reef	3	4	2¾	4½	Do.
	From Caronkaway Reef to San Luis Pass	5½	6½	5¼	6¾	Do.
	At anchorage in West Bay, between Caronkaway Point and the Deer Islands	4	5	3¾	5½	Do.
	At the anchorage off entrance to Chocolate Bay	5	6	4¾	6½	Do.
	Over Bar into San Luis Pass	7½	8½	7¼	8¾	Coast Survey, 1853.
	At the anchorage above San Luis Island	16	17	15¾	17½	Coast Survey, 1867.
	Through to Oyster Bay	2	3	1¾	3½	Do.
Brazos River	Over Bar*	7	8	6¾	8½	Coast Survey, 1858.
	Up to Velasco	11	12	10¾	12½	Do.
	At the anchorage	13	14	12¾	14½	Do.
MATAGORDA BAY and tributaries.	Entrance over Bar* through Pass Cavallo	6½	8	6¼	8¼	Coast Survey, 1874.
	From Inner Bar Buoy to abreast of Pelican Island†	13	14½	12¾	14¾	Do.
	At the anchorage under north shore of Decro's Point	33	34½	32¾	34¾	Do.
	From abreast of Pelican Island to Swash Buoy	10½	12	10¼	12¼	Do.
	From Swash Buoy to Half-Moon Reef Light-house	10	11½	9¾	11¾	Coast Survey, 1866–'71.
	From abreast of Half-Moon Reef Light to Dog Island Reef	7	7¾	(‡)	(‡)	Coast Survey, 1859.
	Over the Reef	2	2¾	(‡)	(‡)	Do.
	From Dog Island Reef to anchorage off Matagorda	6	6¾	(‡)	(‡)	Do.
	From Matagorda to Dressing Point (entrance to Live-Oak Bay)	5	5¾	(‡)	(‡)	Coast Survey, 1871–'72.
	In Live-Oak Bay	2½	3¼	(‡)	(‡)	Do.
	From abreast of Dressing Point to Head of the Bay	3½	4	(‡)	(‡)	Do.
	Anchorage for Strangers, Outside Bar†	42	42½	41¾	43¾	L't-House Board, 1880.
	Through McHenry's Bayou to Espiritu Santo Bay—Over Bar	4½	4¾	3¾	5½	Coast Survey, 1874.
	In the Bayou	8	8½	7¼	9	Do.
	From Swash Buoy to Indianola Wharves	9	9½	8½	10	Coast Survey, 1860.
	From Swash Buoy to entrance to Lavaca Bay	8	8½	7¼	9	Coast Survey, 1871.
	Over Bar by East Channel into Lavaca Bay	6½	6¾	5¾	7½	Do.
	Over Bar by West Channel into Lavaca Bay	9	9½	8½	10	Do.
	Over Bar by Middle Channel into Lavaca Bay	8	8½	7½	9	Do.
	At anchorage in Lavaca Bay	8	8½	7½	9	Do.
	Up the Bay to Point Comfort Bar	7½	7¾	6¾	8½	Do.
	Over Point Comfort Bar	7	7½	6½	8	Do.
	From Point Comfort Bar to Port Lavaca	7	7½	6½	8	Do.
	To Head of Bay	3	3½	2½	4	Do.
	At anchorage in Cox's Bay	4	4½	3½	5	Do.
	In entrance to Keller's Bay	5	5½	4½	6	Do.
	At anchorage in Keller's Bay	5	5½	4½	6	Do.
	Over Bar into Carankaway Bay	1½	2¼	(‡)	(‡)	Do.
	At the anchorage	7	7¾	(‡)	(‡)	Do.
	To the Head of the Bay	3	3¾	(‡)	(‡)	Do.
	Entrance to Turtle Bay over Wells' Point Bar	4	4¾	(‡)	(‡)	Do.
	At the anchorage abreast of Starboard Point	4½	5¼	(‡)	(‡)	Do.
	To Head of Turtle Bay	1½	2¼	(‡)	(‡)	Do.
	Entrance to Tres Palacios Bay	5½	6¼	(‡)	(‡)	Do.

* Constantly changing; cannot be entered without a pilot.
† Not only the bar but the shape of Pelican Island changes often. Strangers must anchor outside and wait for a pilot.
‡ Not sufficient data as yet obtained for Spring Tides.

Table of depths, Gulf Coast—Continued.

TEXAS.

Places.	Limits between which depths are given.	Least water in channel. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
MATAGORDA BAY and tributaries—Continued.	Up the Bay to High Point	5½	6¼	(*)	(*)	Coast Survey, 1871.
	To Head of the Bay	2	2¾	(*)	(*)	Do.
Espiritu Santo Bay	Over Pass Cavallo Bar† and through McHenry's Bayou (Saluria Entrance)	4½	4¾	3¾	5½	Coast Survey, 1874.
	Over Inner Bar from McHenry's Bayou	2⅛	2¾	1¾	3⅛	Do.
	Through entrance north of Bayucos Island	3	3½	2½	4	Do.
	At the anchorage to the westward of Grass Island	8	8½	7⅛	9	Coast Survey, 1872.
	Through the Bay to Steamboat Pass	6½	6¾	(*)	(*)	Do.
	Through Steamboat Pass into San Antonio Bay	3½	3¾	(*)	(*)	Do.
San Antonio Bay	Through the Bay from Steamboat Pass to False Live-Oak Point	4¼	4⅛	4	5¾	Do.
	Over Panther Point Reef	4¼	4⅛	4	5¾	Coast Survey, 1873–'75.
	From False Live-Oak Point to "Second Chain of Islands"	4	4¼	3¾	5½	Do.
	From "Second Chain" to "Third Chain of Islands"	2⅛	2¾	2¼	4	Do.
	From "Third Chain" to Cape Carlos (eastern entrance to Aransas Bay)	3¼	3⅛	3	4¾	Do.
	At anchorage in Mezquit Bay	4	4¼	3¾	5½	Do.
	Through San Antonio Bay from abreast of False Live-Oak Point to Hines' Bay Entrance	5	5¼	4¾	6⅛	Do.
	Through San Antonio Bay from Steamboat Pass to Hines' Bay Entrance	4½	4¾	4¼	6	Do.
	At the anchorage in Hines' Bay	4	4¼	3¾	5½	Do.
	Up Hines' Bay to Crescent Village	2	2¼	1¾	3½	Do.
	From abreast of False Live-Oak Point to Marsh Point (entrance to Mission Bay)	4	4¼	3¾	5⅛	Do.
	From off Signal Island to Marsh Point	4	4¼	3¾	5⅛	Do.
	From Marsh Point to Mission Bay	3	3¼	2¾	4⅛	Do.
	Through Cedar Bayou from the Gulf to Mezquit Bay	3¼	3⅛	3	4¾	Coast Survey, 1875.
	Through Ayres' Dug-Out over Ayres' Reef	2¾	3	2⅛	4¼	Do.
	Through Belden's Dug-Out over Third Chain of Islands	3	3¼	2¾	4⅛	Do.
	Through Cape Carlos Dug-Out to Aransas Bay	3⅛	3¾	3⅛	5	Do.
Aransas Bay and tributaries	Over Bar† at Aransas Pass	7	7¼	6¾	8⅛	Do.
	At anchorage under Saint Joseph's Island between it and Lydia-Ann Islands	18	18¼	17¾	19⅛	Coast Survey, 1868.
	Through Lydia-Ann Channel to Mud Island	6¼	6½	6	7¾	Coast Survey, 1868–'69.
	At anchorage abreast of Aransas	11	11¼	10¾	12⅛	Coast Survey, 1868.
	From Aransas Pass to Mud Island	7⅛	7¾	7½	9	Coast Survey, 1868–'69.
	From abreast of Mud Island to Nine-Mile Point	8	8¼	7¾	9⅛	Coast Survey, 1869–'75.
	From abreast of Nine-Mile Point to entrance to Copano Bay	9	9⅛	8¾	10⅛	Coast Survey, 1875.
	From abreast of Nine-Mile Point to Cape Carlos Dug-Out (over Long Reef)	4¾	5	4½	6¼	Do.
	Passage between Long and Half-Moon Reefs	6⅛	6¾	6¼	8	Do.
	Through Corpus Christi Bayou to Corpus Christi Bay (Ransom's Point)	5¼	5¾	5	6¾	Coast Survey, 1869.
	Over Lap Reef in Copano Bay Entrance by the South Channel	6½	7	6¼	8	Coast Survey, 1875.
	Over Lap Reef by the North Channel	7	7½	6¾	8⅛	Do.
	Through Copano Bay to mouth of Aransas River	4	4½	3¾	5½	Do.
	Through Copano Bay to entrance to Puerto Bay	6	6½	5¾	7½	Do.

* Not sufficient data as yet obtained for Spring Tides.

† Shifting sand-bar.

Table of depths, Gulf Coast—Continued.

TEXAS.

Places.	Limits between which depths are given.	Least water in channel — Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Aransas Bay and tributaries—Continued.	Over Bar into Puerto Bay	3½	4	3¼	5	Coast Survey, 1875.
	Through Puerto Bay to Red Fish Cove	4	4½	3¾	5¼	Do.
	Across Copano Bay to Mission Bay	4	4½	3¾	5¼	Do.
	Over Bar into Mission Bay	4	4½	3¾	5¼	Do.
	At anchorage in Bay	2½	3	2¼	4	Do.
	Through Jordan's Pass across Copano Reef	8	8½	7¾	9¼	Do.
	Through Smith's Channel across Copano Reef	8	8½	7¾	9¼	Do.
	Over Bar from Aransas Bay into Saint Charles' Bay	1½	1¾	1	2¾	Do.
	Up Saint Charles' Bay to Marsh Cove	3½	4	3¼	5	Do.
	Through the Bay to its Head	2	2½	1¾	3¼	Do.
	In Steamboat Channel between Aransas and Corpus Christi Bays)	6½	7	....	....	Coast Survey, 1868–'69.
Corpus Christi Bay and tributaries.	Over Bar* to Corpus Christi Pass	3	3¾	2¾	4½	Coast Survey, 1875.
	Through Corpus Christi Pass to Crane Islands	7	7¾	6¾	8½	Coast Survey, 1868–'69.
	From the Pass to entrance to Corpus Christi Bay (over Inner Bar)	2½	3½	2¼	4	Do.
	At the anchorage inside Inner Bar	13	13¾	12¾	14½	Do.
	At the anchorage abreast of Corpus Christi	14	14¾	13¾	15½	Do.
	Through the Bay to Ransom's Point	10½	11½	10¼	12	Do.
	From Corpus Christi to Ransom's Point	10½	11½	10¼	12	Do.
	From the Pass to entrance to Nueces Bay	9	9¾	8¾	10½	Do.
	In entrance to Nueces Bay	1	1¾	¾	2½	Do.
	Across Corpus Christi Bay to entrance to Ingleside Cove	7½	8½	7¼	9	Do.
	Anchorage in Cove	6	6¾	5¾	7½	Do.
	At the wharves in Ingleside Cove	3	3¾	2¾	4½	Do.
	At the Corpus Christi Wharves	8	8¾	7¾	9½	Do.
	Through Shallow Bay from Railroad Pier to Ransom's Point	5	5½	4¾	6½	Do.
	Entrance to Laguna Madre‡, Over Bar	2½	3½	2¼	4	Do.
Brazos Santiago	Over Bar†	6	6¾	5¾	7	Coast Survey, 1867.
	At the anchorage off Brazos Wharf	21	21¾	20¾	22	Do.
	In the Bay	3–5	3¾–5¾	2¾–4¾	4-6	Do.
Rio Grande	Over Bar	4	5	3¾	5	Coast Survey, 1853.
	At the anchorage abreast of Bagdad	18	19	17¾	19	Do.

FOREIGN HARBORS ADJACENT TO THE ATLANTIC AND GULF COASTS.—WEST INDIES AND MEXICO.

BERMUDA ISLAND.						
Saint George's Harbor	To Murray Anchorage:					
	By East Channel	30	32½	28¾	33¾	British Admiralty, 1855.
	By West Channel	18	20½	16¾	21¾	Do.
	Through The Narrows	23	25½	21¾	26¾	Do.
BAHAMA ISLANDS.	New Providence Island:					
Nassau Harbor	To the anchorage off Navy Wharf	14	17	13¾	17½	British Admiralty, 1866.
ISLAND OF CUBA.						
Matanzas Harbor	To the anchorage off Point Maya	72	84½	72	84¾	British Admiralty, 1860.
	To the anchorage off City of Matanzas	54	66½	54	66¾	Do.
Havana Harbor	To the anchorage	36	39	35¾	39¼	Spanish Surveys, 18[illegible]4
Bahia Honda	To the anchorage	42	44	42	44	U. S. Hydr. Office, 1873
MEXICO, GULF COAST.						
Tampico Harbor	To anchorage inside the Bar	[illegible]	[illegible]	10¾	12¾	Spanish Surveys, 1878.
Vera Cruz Harbor and anchorages.	To anchorage off San Juan de Ulloa	27	29	26¾	29¾	French Admiralty, 1841
	To anchorage under Sacrificios Island	48	50	47¾	50¾	Do.
	To anchorage off Anton Lizardo	42	45	41¾	45¾	Do.

* Shifting bar. † Shifting and dangerous bar. ‡ No hydrographic survey. About 1½ feet may be taken through to Point Isabel.

Table of depths, vicinity of Atlantic and Gulf Coasts.

FOREIGN HARBORS ADJACENT TO THE ATLANTIC AND GULF COASTS.—MEXICO.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
MEXICO, Gulf Coast—Continued.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	
Coatzacoalcos Rino	To anchorage in river	12½	14½	12	15	U. S. Hydr. Office, 1848.
Laguna de Terminos	To anchorage off the town	12	13½	12	13½	U. S. Hydr. Office, 1873.
MEXICO, PACIFIC COAST.						
Mazatlan Harbor	To anchorage inside Blossom Rocks	27	31½	26½	32	British Admiralty, 1828.
Guaymas Harbor	To anchorage off Pajaros Island	42	44½	41½	45	U. S. Hydr. Office, 1874.
LOWER CALIFORNIA.						
La Paz Bay	To anchorage off the town	18	21	17½	21½	Do
San Jose del Cabo Bay	To the anchorage	85	89	84½	89½	British Admiralty, 1839
San Lucas Bay	To the anchorage	66	70	65¾	70½	Coast Survey, 1871.
Almejas Bay	Through Rehusa Channel to anchorage	24	28	23¾	28½	U. S. Hydr. Office, 1873
Magdalena Bay	To anchorage in Man-o'-war Cove	58½	62½	58	62¾	Coast Survey, 1871.
	To anchorage, Eastern Part of Bay	30	34	29½	34½	Do.
Santa Maria Bay	To the anchorage	60	64	59½	64½	U. S. Hydr. Office, 187?.
San Juanico	To the anchorage under San Juanico Point	30	34	29¾	34½	Do.
Ballenas Bay	To anchorage off mouth of San Ignacio Lagoon	27	31	26¾	31½	U. S. Hydr. Office, 1875.
San Hypolito Bay	To anchorage under San Hypolito Point	33	37	33¾	37½	Do.
San Bartolomeo Bay	To anchorage	48	54½	47½	55	U. S. Hydr Office, 1873.
Playa Maria Bay	To the anchorage	33	30½	32½	40	British Admiralty, 1847.
Port San Quentin	To the anchorage above Sextant Point	13½	18	13½	18	U. S. Hydr. Office, 1875.
San Martin Island	To anchorage in Hassler Cove	48	51½	48	51½	Do.
Colnett Bay	To the anchorage	42	46	42	46	Do.
San Tomas Anchorage	To the anchorage	45	50	44¾	50½	Do.
Todos Santos Bay	To Enseñada Anchorage	30	33½	30	33¾	Do.

TABLE OF DEPTHS, PACIFIC COAST.

CALIFORNIA.*

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides, at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
San Diego Bay	Over the Bar	21	25¾	18½	27½	Coast Survey, 1856, '78.
	From Inside Bar to La Playa	20	24¾	17½	26½	Do.
	At the anchorage between Ballast Point and La Playa	34½	39¼	32	41	Coast Survey, 1856.
	From abreast of La Playa Wharf to New San Diego	35	39¾	32½	41½	Do.
	At New San Diego Wharves	14–16	18¾–20¾	11½–13½	20½–22½	Do.
	Anchorage off New San Diego	42	46¾	39½	48½	Do.
	From abreast of New San Diego to abreast of Sweet-Water Valley	19	23¾	16½	25½	Do.
	Anchorage off Sweet-Water Valley	21	25¾	18½	27½	Do.
	To Head of Bay	1	5¾	—1½	7½	Do.
False Bay	Over Bar †	3	7¾	½	9½	Do.
	At the anchorage	17	21¾	14½	23½	Do.
Newport Bay	Over Bar ‡	4½	8	2	11	Coast Survey, 1878.
	From inside Bar to Newport Landing	5	8½	2½	11½	Do.
	At the anchorage outside the Bar	54	57½	51½	60½	Do.
San Pedro Bay	At the anchorage between the Landing and Dead-man's Island	13	17¾	11½	20½	Coast Survey, 1873.
Catalina Harbor	Up to Ballast Point	24	28¾	22½	31¾	Coast Survey, 1870.
	At the anchorage	30	34¾	28½	37¾	Do.
Isthmus Cove	At the anchorage	48	52¾	46½	55¾	Coast Survey, 1873.
	Anchorage in Fisherman's Harbor	48	52¾	46½	55¾	Do.
Sanclemente Island and Harbors.	At anchorage in Smuggler's Cove or Southeast Anchorage	54	58¾	53	60½	Coast Survey, 1878–'79.
	At anchorage in Northwest Harbor	28½	33½	27½	35	Coast Survey, 1879.
Monica Bay	At anchorage in Malaga Cove	24	29	23	30½	Coast Survey, 1876.
	At anchorage off Santa Monica Wharf	21	26	20	27½	Do.
	At end of wharf	22	27	21	28½	Do.
	At anchorage in Keller's Shelter §	36	41	35	42½	Do.
	At anchorage in Dume Cove	36	41	35	42½	Do.
Anacapa Island and Harbors	At anchorage south of eastern end of the island	39	43½	38	45	Coast Survey, 1855.
	At anchorage south of the Boat Passage	66	70½	65	72	Do.
	Through the Boat Passage	3	7½	2	9	Do.
Santa Cruz Island and Harbors	At anchorage in Smuggler's Cove (eastern end of island)	19½	24	18½	25½	Do.
	At Outer Anchorage north of the Cove	60	64½	59	66	Do.
	At Inner Anchorage north of the Cove	48	52½	47	54	Do.
	At Shaw's Anchorage	27	31½	26	33	Do.
	In Forney's Cove	30	34½	29	36	Coast Survey, 1874.
	At anchorage in Prisoner's Harbor	72	76½	71	78	Coast Survey, 1875.
	At Inner Anchorage off Steamboat Wharf	31½	36	30½	37½	Do.
	At end of wharf	2½	7	1½	8½	Do.
	At anchorage in Tinker's Harbor	30	34½	29	36	Do.
	Through Anacapa Passage	198	202½	197	204	Coast Survey, 1855.
	Through Santa Cruz Channel	144	148½	143	150	Coast Survey, 1873–'74.
Santa Rosa Island and Harbors	At northwest anchorage in Beecher's Bay	30	34½	29	36	Coast Survey, 1876.
	At southeast anchorage in Beecher's Bay	39	43½	38	45	Coast Survey, 1873–'74.
	At end of wharf in Northwest anchorage	11	15½	10	17	Coast Survey, 1876.
	At anchorage under Black Point	13	17½	12	19	Do.
	At anchorage in "Johnson's Lee"	36	40½	35	42	Do.
	At anchorage under Ford Point	24	28½	23	30	Do.

* The two high waters and two low waters of the same day vary in height as the moon's declination varies: That is, when the declination is nothing the difference between any two successive high or low waters is very small; but when the declination is greatest either south or north the difference is greatest. The depths given in this table are computed from the mean of the *lowest* low waters.

† Dangerous except in smooth weather.

‡ Shifting bar. Cannot be entered by strangers.

§ No harbor here with wind anywhere to the westward of south.

Table of depths, Pacific Coast—Continued.

CALIFORNIA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
San Miguel Island and Harbors.	At anchorage in Cuyler's Harbor	39	43¾	38	45	Coast Survey, 1875–'76.
	At anchorage in Tyler's Bight	42	46¾	41	48	Do.
	At anchorage in Adams' Cove	24	28¾	23	30	Do.
	A anchorage in Simonton Cove	24	28¾	23	30	Do.
	Through San Miguel Passage	102	106¾	101	108	Do.
Santa Barbara Harbor	At the anchorage near the wharf	20	24½	19½	26	Coast Survey, 1869.
	At end of wharf	19	23½	18½	25	Do.
Coxo Harbor	At the anchorage	27	31½	26½	33	Do.
Point Sal Anchorage	Outer anchorage	39	43½	38½	45	Coast Survey, 1867.
	Inner anchorage*	28½	33	27½	34½	Do.
San Luis Obispo Bay	At the anchorage	25½	30	24½	31½	Coast Survey, 1875.
	At mooring-buoy off People's Wharf	25	29½	24	31	Do.
	At People's Wharf	16	20½	15½	21½	Do.
	At mooring-buoy off Harford's Wharf	18	22½	17½	23½	Do.
	At Harford's Wharf	12	16½	11½	17	Do.
San Simeon Harbor	At the anchorage	24	28½	23½	30	Coast Survey, 1852.
Monterey Bay and Harbors	At the anchorage in Monterey Harbor	24	28¾	23½	30	Coast Survey, 1856.
	At Monterey Wharf	7	11¾	6½	13	Do.
	Anchorage off Gibson's Landing	27	31¾	26½	33	Do.
	At the anchorage in Sauquel Cove	27	31¾	26½	33	Coast Survey, 1855.
	At the anchorage in Santa Cruz Harbor	30	35½	28¾	37½	Coast Survey, 1853.
	At the landing near Observatory	4½	9¾	3½	11¾	Do.
Point Año Nuevo	At the anchorage off the wharf	19	24	18½	25	Coast Survey, 1853–'56.
Half-Moon Bay	At the anchorage to the northwestward of Amesport Landing	27	32	26½	33	Coast Survey, 1863.
	At Amesport Landing Wharf	12½	17½	12	18½	Do.
	At Wharf-end under Pillar Point	2	7	1½	8	Do.
Whaleman's Harbor	At the anchorage †	15	.....	.....	.....	Do.
SAN FRANCISCO BAY and tributaries.	Over bar from the southward or from sea to The Golden Gate	33	37¾	32	39	Coast Survey, 1858–'73.
	Over bar from the northward to The Golden Gate	30	34¾	29	36	Do.
	Over bar alongshore from southward	34½	39½	33½	40½	Do.
	Through Bonita Channel from northward	48	52¾	47	54	Do.
	Through The Golden Gate to abreast of Fort Point	122	126¾	121	128	Coast Survey, 1873.
	From abreast of Fort Point to Alcatraz Island	42	46¾	41	48	Do.
	From abreast of Alcatraz Island to anchorage off San Francisco	52	56¾	51	58	Coast Survey, 1855–'73.
	At the anchorage between Rincon Rock and Steamboat Point	48	52¾	47	54	Do.
	At the anchorage between Oakland Railroad Wharf and Yerba Buena Island	27	32	26	33½	Do.
	At the anchorage under north shore of Fort Point	30	34¾	29	36	Coast Survey, 1873.
	At Fort Point Wharf	19	24½	17¾	25¾	Coast Survey, 1858–'73.
	Anchorage of Potrero Landing	34½	39¾	33½	41½	Do.
	Through the bay to Point San Bruno	22½	27¾	21½	39½	Do.
	From abreast of Point San Bruno to Potrero Point	26	31½	24¾	32¾	Do.
	To head of bay at Calaveras Point	15	20½	13¾	21¾	Do.
	To the northward toward San Pablo from abreast of Alcatraz Island to Bluff Point	54	59	53	60	Coast Survey, 1855.
	From abreast of Bluff Point to Point San Pablo	37	43	30½	44	Coast Survey, 1856–'63.
	In channel between Southampton Shoal and Point Richmond	26	32	25½	33	Do.

* Holding-ground not good; hard sand. † Rarely used. Not marked; and no sufficient tidal data.

Table of depths, Pacific Coast—Continued.

CALIFORNIA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
SAN FRANCISCO BAY and tributaries—Continued.	In Bight between Point Bonita and Point Diablo	39	43¾	38	45	Coast Survey, 1858–'73
	At the anchorage off Oakland Wharf	33	38	32	39½	Do.
	At end of wharf	30	35	29	36½	Do.
	Over bar* into San Antonio Creek	10	16	9	17	U. S. Engineers, 1881.
	Up the creek to Oakland	10	16	9	17	Do.
	To Brooklyn, at head of creek	2	8	1	9	Coast Survey, 1858–'73.
	At end of Alameda Railroad Wharf	7	12	6	13½	Do.
	Over bar to San Leandro Bay	1	7	0	8	Coast Survey, 1855–'58.
	Up to Alameda Bridge	14	20	13	21	Do.
	At anchorage off Dry Dock at Point Avisadera (Hunters' Point)	60	66	59	67	Do
	Over bar to Ravenswood	7	14½	6½	15½	Do.
	At Ravenswood Wharf	16	23½	15½	24½	Do.
	Over bar into Angelo Creek	2	9	½	10	Do.
	From Angelo Creek into Steinberger's Creek	4	11	2½	12	Do.
	Over bar into Redwood City Creek	15	22	14½	23	Do.
	Up the creek to Redwood City	2	9	1½	10	Do.
	Over bar into Guadalupe River	3	10½	2½	11½	Do.
	Over bar into Alviso Slough	6	13½	5½	14½	Do.
	Up the slough to Alviso	1	8½	½	9½	Do.
	Over bar into Coyote Creek	3	8½	1¾	9¾	Do.
	Over bar into Mud Creek	3	8½	1¾	9¾	Do.
	Entrance to Mowry's Creek	7	14½	6½	15½	Do.
	Entrance to Mowry's Creek eastward of Calaveras Point	3	10½	2½	11½	Do.
	At anchorage in Horse-Shoe Bay	16	21	15	22	Coast Survey, 1855.
	Entrance to Richardson's Bay, between Peninsula and Saucelito Points	14	19	13	20	Do.
	At Saucelito wharves	8	13	7	14	Do.
	At Saucelito Point Wharf	21	26	20	27	Do.
	At anchorage off Saucelito Point	18	23	17	24	Do.
	At anchorage under Peninsula Point	27	32	26	31	Do.
	Up to wharf at Point Isabel	1	6	0	7	Do.
	In entrance to San Pablo Bay, between San Pedro and San Pablo Points	75	81	74½	82	Coast Survey, 1858, '63.
	At the anchorage between Petaluma and Napa Creeks	15	21	14½	22	Do.
	At the anchorage off Penole Point	27	33	26½	34	Do.
	To entrance to Petaluma Creek	12	18	11½	19	Coast Survey, 1860
	In the entrance to creek	13	19	12½	20	Do.
	Up the creek to mouth of San Antonio Creek	12	18	11½	19	Do
	From off San Antonio Creek to Lakeville Landing	7	13	6½	14	Do.
	Abreast of Lakeville Landing	16	22	15½	23	Do.
	From off Lakeville Landing to Rudesill's	4	10	3½	11	Do.
	From Rudesill's to Newtown	2	8	1½	9	Do.
	From Newtown to Petaluma City	1	7	½	8	Do.
	In entrance to Sonoma Creek	2	8	1½	9	Coast Survey, 1856.
	From off Penole Point to entrance to Napa Creek	22½	28½	21¾	29½	Coast Survey, 1860–'64.
	In mouth of Napa Creek	25½	31½	24¾	32½	Do.
	Up the Creek through Mare Island Straits to Vallejo	21	27½	20	28½	Do.
	At anchorage off Navy-Yard	21	30½	23	31½	Do.
	At Vallejo City Wharves	4–11	10½–17½	3	11½	Do.

* The improvement contemplates a channel 200 feet wide and 20 feet deep.

Table of depths, Pacific Coast—Continued.

CALIFORNIA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
SAN FRANCISCO BAY and tributaries—Continued.	From abreast of Navy-Yard to mouth of Napa Slough	19	25½	18	26½	Coast Survey, 1860.
	From Napa Slough to Bull Island Slough	10	16½	9	17½	Do.
	From Bull Island Slough to Suscol Ferry	3	9¼	2	10¼	Do.
	From Suscol Ferry to Napa City	1	7½	0	8½	Do.
	Passage through Raccoon Straits	60	65	59	66	Coast Survey, 1855.
	Through the Straits of Karquines to Benicia	60	66	59¼	67	Coast Survey, 1857–'76.
	At the anchorage off Benicia	33	39	32¼	40¼	Coast Survey, 1866–'76.
	From abreast of Benicia to Suisun Bay	33	39	32¼	40¼	Do.
	At Benicia Wharves	6–18	11–24	5–17	12–25	Coast Survey, 1866–'67.
	Up Suisun Bay from Army Point to mouth of Suisun Creek	12	18	11¼	19¼	Do.
	Up Suisun Bay to Suisun Cut-off	13	19	12¼	20¼	Do.
	Through Suisun Cut off	13	19	12¼	20¼	Do.
	From Suisun Cut-off to Simmons' Point	21	27	20¼	28¼	Do.
	Up Suisun Bay from Army Point by South Channel to Middle Point	13	19	12¼	20¼	Coast Survey, 1866–'76.
	From abreast of Middle Point to Simmons' Point	14	20	13¼	21¼	Do.
	From abreast of Simmons' Point to Sherman Island (mouth of San Joaquin River)	33	39	32¼	40¼	Do.
	From abreast of Simmons' Point to mouth of Sacramento River	11	17	10¼	18¼	Do.
	From Army Point through channel to northward of Roe Island to Gillespie's Point	11	17	10¼	18¼	Do.
	From Army Point through Main Channel to Gillespie's Point	19½	25½	18¾	26¾	Do.
	From abreast Gillespie's Point to Sherman Island	21	27	20¼	28¼	Do.
	In entrance to Suisun Creek	7	13	6¼	14¼	Coast Survey, 1867.
	Up Suisun Creek to Suisun City	2	7½	1¼	9¼	Do.
	In Western Entrance to Montezuma Creek	10	15	9¼	15¼	Do.
	At anchorage under Seal Island	27	33	26¼	34¼	Do.
	At entrance to Roaring River	1½	6½	1	6¾	Do.
	Through Roaring River to junction with Montezuma Creek	3	8	2¼	8¼	Do.
	Through Spoonbill Creek	2	7	1¼	7¼	Do.
	Through Mallard Slough	1	6	¼	6¼	Do.
	Up New York Slough to Pittsburgh Landing	5	10	4¼	10¼	Coast Survey, 1871.
	Through New York Slough to San Joaquin River	5	10	4¼	10¼	Do.
	Through Middle Slough from Suisun Bay to San Joaquin River	7	12	6¼	12¼	Do.
	Through Middle Slough to Pittsburgh Landing	7	12	6¼	12¼	Do.
	Up Montezuma Creek by Eastern Entrance from Tongue Shoal to Roaring River	4½	9½	4	9¾	Coast Survey, 1867.
	Through Rock Creek from Roaring River to Honker Bay	4½	9½	4	9¾	Do.
	Up Montezuma Creek from mouth of Roaring River to Tule Island	3	8	2¼	8¼	Do.
	At Collinsville Wharf (entrance to Sacramento River)	11	16	10¼	16¼	Coast Survey, 1866.
	In mouth of Sacramento River	22½	27½	22	27¾	Do.
	Up the river for two miles*	16	21	15¼	21¼	Coast Survey, 1867.
	Sacramento River to Perry's Landing	14	19	13¼	19¼	Do.
	In mouth of San Joaquin River	40	45	39¼	45¼	Do.
	Up the river to New York Slough	22½	27½	22	27¾	Do.

* No survey beyond this point.

Table of depths, Pacific Coast—Continued.

CALIFORNIA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
SAN FRANCISCO BAY and tributaries—Continued.	Through New York Slough to Pittsburgh Landing	25½	30½	25	30¾	Coast Survey, 1867.
	Up San Joaquin River to Kimball's Island	22½	27½	22	27¾	Do.
	From Kimball's Island to eastern end of West Island	31½	36½	31	36¾	Do.
	At anchorage off Antioch	46½	51½	46	51¾	Do.
	At Antioch Wharves	18	23	17½	23½	Do.
Ballenas Bay	At the anchorage	33	38	32	39½	Coast Survey, 1854.
Cordell Bank (off Point Reyes)	Shoalest water on the bank	150	....	....	....	Coast Survey, 1873.
	Deepest water on the bank	210	....	....	....	Do.
Drake's Bay	At the anchorage under eastern shore of Point Reyes	21	26	20	27½	Coast Survey, 1860.
	At anchorage one mile to the westward of Drake's Estero	28½	33½	27½	35	Do.
	In entrance to Drake's Estero	8	13	7	14½	Do.
	At anchorage inside	10	15	9	16½	Do.
Tomales Bay	Over bar at entrance	10	14¾	9	16¾	Coast Survey, 1861.
	From inside the bar to Hog Island	*10	14¾	9	16¾	Do.
	From abreast of Hog Island to Muldrow City	†10	20¾	15	22¾	Do.
	From abreast of Muldrow City to Rancheria	19	23¾	18	24¾	Do.
	From abreast of Rancheria to head of bay	1	5½	0	7¾	Do.
	Through Tom's Point Channel to abreast of Smith's Landing	7	11¾	6	12¾	Do.
	At wharves at Smith's Landing	0	4¾	—1	5¾	Do.
	At anchorage in bay abreast of Tom's Point	24	28¾	23	29¾	Do.
	In mouth of Arroyo San Antonio	3	7¾	2	8¾	Do.
	In White Gulch	18	22¾	17	23¾	Do.
	At anchorage off Muldrow City	18	22¾	17	23¾	Do.
	At anchorage off Rancheria	27	31¾	26	32¾	Do.
Bodega Bay	At the Outer Anchorage	24	29	23½	31	Coast Survey, 1862.
	Over the bar‡ into Inner Bay	8	13	7½	15	Do.
	Through Inner Bay to its head	2	7	1½	9	Do.
	At anchorage southwest of wharves at Bay Head	13	18	12½	20	Do.
	At the wharves	5	10	4½	12	Do.
Shelter Cove	At the Outer Anchorage	18½	23½	17¾	25½	Coast Survey, 1880.
	At Inner Anchorage	5	9¾	4¼	11¾	Do.
Mendocino Bay	At anchorage in Outer Bay	33	37¾	32¼	39¾	Coast Survey, 1872.
	At anchorage above the wharves	8	12¾	7¼	14¾	Do.
	At Railroad Wharves	13-18	17¾-23¾	12¼-18¼	19¾-25¾	Do.
Humboldt Bay	In the entrance§	12	17½	11	18½	Coast Survey, 1875.
	Over Inner Bar by West Channel	13	18½	12	19½	Coast Survey, 1871.
	Through East Channel from entrance to Bucksport	7	12½	6	13½	Do.
	At anchorage in West Channel abreast of Light-House	25½	31	24½	32	Do.
	At anchorage in East Channel off mouth of Elk River	36	41½	34	42½	Do.
	At anchorage abreast of Humboldt	19½	25	18½	26	Do.
	From abreast of Bucksport to Eureka	7	12½	6	13½	Do.
	At Eureka Wharves	6	11½	5	12½	Do.
	From abreast of Eureka to Arcata Wharf	4	9½	3	10½	Do.
	At Arcata Wharf	4	9½	3	10½	Do.
	At anchorage off Bucksport	22½	28	21½	29	Do.
	Channel through southern arm of Bay to its head (Meyer's Landing)	0	5½	—1	6½	Do.

* Over bar abreast of Sand Point. † Over Hog Island Bar. ‡ Shifting sand-bar. § This bar shifts constantly, both in depth and direction. It cannot be entered without a pilot, and then only in fine weather.

Table of depths, Pacific Coast—Continued.

CALIFORNIA AND OREGON.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Least water in channel. Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Trinidad Harbor	At the Outer Anchorage between Prisoner's Rock and Trinidad Head	42	48	41	49½	Coast Survey, 1872.
	At moorings inside of Prisoner's Rock	27	33	26	34½	Do.
	At the wharf (east side of Trinidad Head)	14	20	13	21½	Do.
Crescent City Harbor	In the entrance* by Whaler's Island	25	31½	24	32½	Coast Survey, 1859
	In the entrance between the Light-House and Steamboat Rock	25	31½	24	32½	Do.
	At the anchorage between Wharf and Fauntleroy's Rock	19½	25¾	18½	26¾	Do.
	At Inner Anchorage above the wharf	13½	19¾	12½	20¾	Do.
	At the wharf	14	20½	13	21½	Do.
Chetko Cove (Oregon)	At the anchorage (outer)	39	43	38	44½	Coast Survey, 1873
	At the anchorage (inner) between Salmon and Bar Rocks	19½	23½	18½	24½	Do.
	Over Bar into Chetko River	1	5	0	6½	Do.
	At anchorage in Chetko River (off "Miller's")	7	11	6	12½	Do.
Macklin Cove	At the anchorage	12	16	11	17½	Do.
Mack's Reef	At the Outer Anchorage	36	40	35	41½	Coast Survey, 1874.
	At the Inner Anchorage	24	28	26	29½	Do.
Hunter's Cove	Entrance by Main Channel (between Cape Sebastian and Hunter's Island)	27	31	26	32½	Coast Survey, 1873.
	At anchorage in Cove	22½	26½	21½	27½	Do.
	Entrance over bar inshore of Hunter's Island	10	14	9	15½	Do.
Port Orford or Ewing Harbor	At the Outer Anchorage† (between Tichenor's Rock and Coal Point)	63	69½	62½	70½	Coast Survey, 1853.
	At Inner Anchorage (about 300 yards S. of Battle Rock)	21	27½	20½	28½	Do.
Cape Orford	Through the "Steamer Channel" between Cape Orford and Cape Orford Reef	52	58½	51½	59½	Coast Survey, 1871.
Coquille River	In the entrance ‡	3	9½	2½	10½	Coast Survey, 1860.
	At the anchorage	16	22½	15½	23½	Do.
	Up the river to wharf	7	13½	6½	14½	Do.
Koos Bay and River	Over bar ‡	8	14½	7½	15½	Coast Survey, 1865.
	At the anchorage inside the bar (off entrance to South Slough)	27	33½	26½	34½	Do.
	From anchorage up to Empire City	17	23½	16½	24½	Do.
	At Empire City Wharf	16	22½	15½	23½	Do.
	From abreast of Empire City to Hayne's Slough	15	21½	14½	22½	Do.
	From abreast of North Bend Point to Marshfield Point	10	15	9½	16	Do.
	Into Poney Slough	1	6	½	7	Do.
	Entrance to North Slough	7	12	6½	13	Do.
	Entrance to Hayne's Slough	7	12	6½	13	Do.
	Northern Entrance to Koos River under Pierce's and Crawford's Points	3	8	2½	9	Do.
	Through Marshfield Channel into Koos River	4	9	3½	10	Do.
	From Marshfield Point to Coal-Bank Slough	10	15	9½	16	Do.
	In Mouth of Coal-Bank Slough	8	13	7½	14	Do.
	In Mouth of Isthmus Slough	7	12	6½	13	Do.
	In Mouth of Kitchen Slough	7	12	6½	13	Do.
	At entrance to South Slough	1	6	½	7	Do.
Umpquah River	Over bar §	12	18	11½	19	Coast Survey, 1852.
	At the anchorage in Winchester Bay	13	19	12½	20	Do.
	Up the river to wharf below Middle Ground	6	11	5½	13	Do.

* Many rocks and shoals.
† Holding-ground not good.
‡ Shifts constantly. Depths given represent the condition of the bar in October, 1865.
§ Constantly shifting. Cannot be entered without a pilot.

Table of depths, Pacific Coast—Continued.

OREGON.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Umpquah River—Continued	From Winchester Bay by East Channel to Middle Ground	13	19	12½	20	Coast Survey, 1853.
	Through channel east of Middle Ground	10	16	9½	17	Do.
	Through Western Channel to junction above the Middle Ground *	3	9	2½	10	Do.
	At anchorage abreast of Astronomical Station	16	22	15½	23	Do.
Alseya River	Over bar †	7¾	15½	6¾	17	U. S. Engineers, 1880.
	At anchorage on eastern side of Alseya Spit	15	22¾	14	24¼	Do.
Yaquinna Bay and River	Over bar ‡	9	16¼	8	17¾	Lt. House Board, 1870.
	At the anchorage off Newport	30	37½	29	38¾	Coast Survey, 1868.
	From the anchorage by Main (northern) Channel to Coquille Point (entrance to Yaquinna River)	16	23¼	14½	24½	Do.
	From the anchorage through South Channel to Coquille Point	§5	12¼	4½	13½	Do.
	Through the passage between Mud Flat and Sand Flat	2½	9¾	2	11	Do.
	From abreast of Coquille Point to Idlewild Point	18	25¼	16½	26½	Do.
	From Idlewild Point to Oysterville	13	20¼	11½	21½	Do.
	In Hoxie's Cove	1-7	8¼-15¼	—½-13¾	9½-16½	Do.
Tillamook Bay	Over bar ‖	14	20¾	12¾	21¾	Coast Survey, 1866-'67.
	At the anchorage under Kincheloe Point	16	22¾	14¾	23¾	Do.
	At the anchorage under Memaluct Head	11	17¾	9¾	18¾	Do.
	Through the East Channel to Sandstone Point	8½	16¼	7¼	17½	Do.
	From abreast of Sandstone Point to Shell Point	3	9¾	1¾	10¾	Do.
	From abreast of Shell Point to Rock Point (at head of bay)	1	7¾	—½	8¾	Do.
	Through the Middle Channel to Shell Point	6	12¾	4¾	13¾	Do.
	From abreast of Shell Point to Rock Point	1½	8½	¼	9½	Do.
	Through the Western Channel to Pitcher Point	7	13¾	5¾	14¾	Do.
	From abreast of Pitcher Point to Rock Point	2	8¾	¾	9¾	Do.
COLUMBIA RIVER	Over bar by the North Channel ‖	22	29½	21	30½	U. S. Engineers, 1880.
	Over bar by the South Channel ‖	19	26½	18	27½	Do.
	Through North Channel into Baker's Bay	26	33½	25	34½	Coast Survey, 1868.
	Through South Channel into Baker's Bay	17	24½	16	25½	Do.
	At anchorage off Fort Stevens Wharf	36	43½	35	44½	Do.
	At anchorage under Cape Disappointment in Baker's Bay	24	31½	23	32½	Do.
	Up river from Point Adams to Astoria	22	29½	21	30½	Do.
	At the anchorage off Astoria	27	34	26	36½	Do.
	At Astoria Wharf	19	26	18	28½	Do.
	In entrance to Young's Bay	13½	21	12½	22¾	Coast Survey, 1876-'77.
	Through the bay to mouth of Young's River	13	20½	12	22½	Do.
	In entrance to Young's River	24	31½	23	33½	Do.
	From abreast of Sand Island by Northern Channel to Point Ellice	31½	41¾	33¾	43	Coast Survey, 1868.
	Up river from Astoria to Tongue Point	19½	26½	18½	27¾	Do.
	Through Northern Channel from Point Ellice to Gray's Point	13	20½	12½	21½	Do.
	To anchorage on western shore of Gray's Bay	36	43	35½	44½	Do.
	Through Gray's Bay to Alamicut River	6	13	5½	14½	Do.
	From Point Ellice to Tongue Point	14	21	13½	22½	Coast Survey, 1867-'68.
	From Point Ellice to Cementville Lower Wharf	12	19	11½	20½	Do.
	Through Woody Island Channel from Tongue Point to junction with Cordell Channel	13	19½	11¾	20	Do.
	Through Cordell Channel	17	23½	15¾	24	Do.

* No survey above this.
† Constantly shifting. Cannot be entered without a pilot.
‡ Condition of bar in 1870.
§ Over Middle Ground.
‖ Shifting sands.

Table of depths, Pacific Coast—Continued.

OREGON AND WASHINGTON TERRITORY.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
COLUMBIA RIVER—Cont'd.	Through Woody Island Channel from junction with Cordell Channel to Woody Island	15	21½	13¾	22	Coast Survey, 1867'–68
	Through North Channel from Gray's Point across Portuguese Bar	11	18	10½	19½	Do.
	From Portuguese Bar to abreast of Yellow Bluffs	19½	26½	18¾	27¾	Do.
	From abreast of Yellow Bluffs to Jim Crow Point (junction of all channels)	20	26½	18¾	27	Do.
	From Tongue Point through Cathlamet Bay to John Day's Point	9	15½	7¾	16	Coast Survey, 1876.
	In mouth of John Day's River	7	13½	5¾	14	Do.
	Through Cathlamet Bay from John Day's Point to Settler's Point (South Shore Channel)	12	18½	10¾	19	Do.
	From Settler's Point to Prairie Channel	6	12½	4¾	13	Do.
	Channel from Tongue Point to entrance to Prairie Channel	15	21½	13¾	22	Do.
	Through Prairie Channel to Warren's Landing	15	21½	13¾	22	Do.
	By Northern Passage in Prairie Channel under South Shore of Marsh Island	17	23½	15¾	24	Do.
	From Warren's Landing to Southwestern end of Long Island	8	14½	6¾	15	Do.
	Through Prairie Channel to eastern end of Woody Island	18	24½	16¾	25	Do.
	From Prairie Island Channel across the flats to Main Channel at Willow Island	9	15½	7¾	16	Do.
	Marsh Island Creek from Woody Island Channel to Prairie Channel	2	8½	¾	9	Do.
	Through Main Channel from Jim Crow Point to Three Tree Point	39	45½	37¾	46	Do.
	From abreast of Three Tree Point to Puget Island	37	43½	36	44	Do.
	Through Multnomah Slough to Main Channel	9	15½	8	16	Do.
	From Cathlamet Point, S. of Tenasillihee Island, to Puget Island	10	16	9	17½	Do.
	Through Main Channel from west end of Puget Island to Cape Horn	24	29½	23	31½	Do.
	Through Cathlamet Channel to Cape Horn	15	20	14½	22	Do.
	At anchorage off Cathlamet	42	47	41½	49	Do.
	At Cathlamet Wharves	12	17	11½	19	Do.
	In entrance to Westport Slough (Main Channel)	19½	25	18½	27	Do.
	At anchorage off mouth of Slough	19½	25	18½	27	Do.
	Up Westport Slough to Westport	18	23½	17	25½	Do.
	At anchorage off Westport	25½	31	24½	33	Do.
	At Westport Wharf	11	16½	10	18½	Do.
	Through Westport Slough to Wallace's Island Channel	5	9¾	4½	11	Coast Survey, 1876–'77.
	In entrance to Wallace's Island Channel from Main Channel	16	20¾	15½	22	Do.
	Through Wallace's Island Channel	5	9¾	4½	11	Do.
	Main Channel, from abreast of Cape Horn to Bradbury Slough	30	35½	29	37½	Coast Survey, 1876.
	Through Bradbury Slough	17	21¾	16½	23	Coast Survey, 1876–'77.
	From abreast of west end of Grim's Island to Big Slough	45	50½	44	52½	Coast Survey, 1876.
	Anchorage in Big Slough	22	27	21½	29	Do.
	Main Channel, from off Big Slough to lower end of Walker's Island	22	25½	21½	26	Coast Survey, 1877.
	At anchorage off Cleaveland's Landing	22	25½	21½	26	Do.
	Through Fisher's Island Channel	14	17½	13½	18	Do.

Table of depths, Pacific Coast—Continued.

OREGON AND WASHINGTON.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
COLUMBIA RIVER—Cont'd.	Through Walker's Island Channel to Mount Coffin	19	22½	18½	23	Coast Survey, 1877.
	Through Main Channel from lower end of Walker's Island to Rainier	20	23½	(*)	(*)	Do.
	At anchorage off Rainier	30	33½	(*)	(*)	Do.
	At Rainier Wharves	9–18	12½–21½	(*)	(*)	Do.
	Over bar into Cowlitz River	6	9½	(*)	(*)	Do.
	Up the river to Monticello	7	10½	(*)	(*)	Do.
	Up the river to Freeport	5	8½	(*)	(*)	Do.
	Main channel of Columbia River to Sandy Island	21	24½	(*)	(*)	Do.
	Through eastern channel from abreast of Coffin Rock to Kalama	16	19	(*)	(*)	Do
	At anchorage off Kalama	15	18	(*)	(*)	Do.
	At Kalama Wharves	12–19	15–22	(*)	(*)	Do.
	Main Channel, from Sandy Island to Deer Island, northwest end	21	24	(*)	(*)	Do.
	Through Cottonwood Island Channel	21	24	(*)	(*)	Do.
	From off Kalama to Deer Island	19	22	(*)	(*)	Do.
	From off northwest end of Deer Island to Martin's Bluff	31½	33½	(*)	(*)	Coast Survey, 1881.
	From abreast Martin's Bluff to northern entrance to Martin's Slough	21	22¾	(*)	(*)	Do.
	Through Martin's Slough	13	15	(*)	(*)	Do.
	From abreast north end of Martin's Island to Columbia City	22½	24½	(*)	(*)	Do.
	Deepest water in channel between Rainier and Sandy Island	†180	183½	(*)	(*)	Coast Survey, 1877.
	Deepest water betwen Sandy Island and north end of Martin's Island	‡100½	102½	(*)	(*)	Coast Survey, 1881.
	Deepest water between Martin's Island and Columbia City	§69	70¾	(*)	(*)	Do.
	In entrance to Burke's Slough	9	11	(*)	(*)	Do.
	Through Burke's Slough to Martin's Slough	9	11	(*)	(*)	Do.
	At anchorage off Columbia City	‖36	37¾	(*)	(*)	Do.
SHOALWATER BAY	In the entrance by North Channel ¶	22	30½	21	32½	Coast Survey, 1855.
	In entrance by South Channel ¶	25	33½	24	35½	Do.
	At the anchorage under Leadbetter's Point	72	80½	71	82½	Do.
	At the anchorage under Cape Shoalwater	24	32½	23	34½	Do.
	At the anchorage under Toke Point	24	32½	23	34½	Do.
	At the anchorage off Bruceport	36	44	35	46	Do.
	Across the bay to Range Point	15	23	14	25	Do.
	In entrance to Willopa River	15	23	14	25	Do.
	Up Willopa River to one and a half miles above Range Point	15	23	14	25	Do.
	In entrance to North River	6	14	5	16	Do.
	From abreast of Leadbetter's Point southward through the bay to abreast of Oysterville:					
	1. By the Beach Channel	14	22	13	24	Do.
	2. By the Main Channel	34½	42½	33½	44½	Do.
	3. By the East Channel	**8	16	7	18	Do.
	At anchorage off Oysterville	27	35	26	37	Do.
	From off Oysterville by Main Channel to abreast of Diamond City (Long Island)	28½	36½	27½	38½	Do.

* Not sufficient data.
† Nearly abreast of Coffin Rock.
‡ Three-quarters of a mile below Martin's Bluff.
§ One mile above Burke's Slough.
‖ No survey above this (1883).
¶ Constantly shifting; cannot be entered without a pilot.
** Over bar at junction with Main Channel.

Table of depths, Pacific Coast—Continued.

OREGON AND WASHINGTON TERRITORY.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
SHOALWATER BAY—Continued.	Through East Channel to Long Island	21	29	20	31	Coast Survey, 1855.
	From off Diamond City to High Point	25	33	24	35	Do.
	Through East Channel to Long Island Slough	22½	30½	21½	32½	Do.
	Through Long Island Slough to High Point	2	10	1	12	Do.
	From High Point to entrance to Baker's Slough	1	9	0	11	Do.
	In entrance to Bear River	3	11	2	13	Do.
	In entrance to Nasäl River	19½	27½	18½	29½	Do.
	In entrance to South Nemur River	2	10	1	12	Do.
	In entrance to North Nemur River	1	9	0	11	Do.
Gray's Harbor	Over bar *	17	25½	16	27	Coast Survey, 1862
	At anchorage under eastern shore of Point Brown	24	32½	23	34	Do.
	At anchorage in mouth of South Bay, abreast of Point Hanson	42	50½	41	52	Do.
	Up the harbor to abreast of Stearns' Bluff	20	28½	19	30	Do.
	From Point Hanson to mouth of John's River	10	18½	9	20	Do.
	Up South Bay for two miles †	10	18½	9	20	Do.
Nee-ah Harbor (Strait of San **Juan** de Fuca).	At the usual anchorage	30	37½	29	39	Coast Survey, 1852
	At the anchorage between Wa-addah Island and Ba-addah Point	27	34	26	36	Do.
Crescent Bay	At the anchorage ‡	18	25½	16¾	27	Coast Survey, 1852-'53
Fresh-water Bay	At the anchorage	30	37½	28¾	39	British Admiralty, 1847.
False Dungeness Harbor (Strait **of Fuca**).	At anchorage under Ediz Hook	27	34½	25¾	36	Coast Survey, 1852-'55.
	At anchorage on the South Shore	28½	36	27¼	37½	Do.
	From abreast of Ediz Hook Light-house to Head of the Harbor	27	34½	25¾	36	Do.
	At the anchorage at Head of Harbor	39	46½	37¾	48	Do.
New Dungeness Harbor (Strait **of Fuca**).	At the anchorage in the Roadstead	41	48½	39¾	50	Coast Survey, 1855.
	In the entrance to Inner Harbor (over bar)	4	11½	2¾	13	Do.
	At anchorage in Inner Harbor	10	17½	8¾	19	Do.
Washington Harbor (Strait of **Fuca**).	In the entrance	12	19½	10¾	21	Coast Survey, 1881.
	At the anchorage near Head of Harbor	54	61½	52¾	63	Do.
Port Discovery (Strait of Fuca).	At the anchorage under Contractor's Point	90	97½	88¾	99	Do.
	At the upper anchorage (Head of Harbor)	60	67½	58¾	69	Do.
Admiralty Inlet and Harbors	Entrance to Inlet	228	236	226	237	Coast Survey, 1855.
	At anchorage in Admiralty Bay §	65	73	63	74	U. S. Explo'g Exp., 1841.
	In entrance to Port Townshend	63	71	61¼	72½	U. S. Land Office.
	At anchorage off the town	58	66	56¼	67½	Do.
	Entrance to Kilisut Harbor	25	30½	24½	30¾	Coast Survey, 1880.
	Main Channel from Admiralty Head to Foulweather Bluff (entrance to Puget Sound)	324	331	322	334	Coast Survey, 1876.
	At the anchorage under Bush Point	120	127	118	130	Do.
	In entrance to Oak Bay	120	127	118	130	Coast Survey, 1880.
	In mid-channel of bay	78	85	76	88	Do.
	To Head of Bay	18	25	16	28	Do.
	At anchorage under Oak Point	60	67	58	70	Do.
	At anchorage under the Southern Shore	51	58	49	61	Do.
	At anchorage at Head of the Bay	40	47	38	50	Do.
	At anchorage under Marrowstone Point	120	128	118	130	Coast Survey, 1855.
	At anchorage in Mutiny Bay	42	50	40	52	U. S. Expl'g Exp., 1841.
	In entrance to Deer Lagoon	4	12	2	14	Coast Survey, 1876.
	At anchorage in eastern arm of Lagoon	8	16	6	18	Do.
	At anchorage in western arm of Lagoon	7	15	5	17	Do.
PUGET SOUND and tributaries.	From Double Bluff to West Point	300	....	....	....	Land Office Surveys.
	At anchorage off Cultus Bay	48	56	46	58	Do.

* Many shoals.
† No survey beyond this point.
‡ Slight shelter. Unfit for strangers.
§ Open to southeasters, and no good holding-ground.

Table of depths, Pacific Coast—Continued.

WASHINGTON TERRITORY.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Least water in channel. Mean. High water.	Least water in channel. Spring tides at moon's greatest declination. Lower low water.	Least water in channel. Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
PUGET SOUND and tributaries—Continued.	At anchorage in Apple Cove	60	71	58	74	Coast Survey, 1875.
	At anchorage under Point Jefferson	54	65	52	68	Do.
	In entrance to Port Madison	300	311	298	314	Coast Survey, 1868
	At outer anchorage	30	41	28	44	Do.
	In the entrance to Inner Harbor	15	26	13	29	Do.
	At anchorage off town of Port Madison	19½	30½	17½	33½	Do.
	Through Agate Passage into Port Orchard	22½	32½	20½	34½	Do.
	At anchorage in Shilshole Bay	30	40	28½	40½	Coast Survey, 1867.
	In Mouth of Shilshole Creek	2	12	½	12½	Do.
	In mouth of Duwamish Bay	420	......	......	......	Coast Survey, 1875.
	At the anchorage off Freeport	60	71½	57¾	73½	Do.
	At Yesler's Wharf, Seattle	24	35½	21¾	37½	Do.
	At Coal Company's Wharf, Seattle	14	25½	11¾	27½	Do.
	At the anchorage off the town	42	53	40	55	Do.
	At the anchorage in Murden's Cove	21	32	19	34	Do.
	At the anchorage in Eagle Harbor	34½	45½	32½	47½	Do.
	At the anchorage under Wing Point	45	56	43	58	Do.
	At the upper anchorage	27	38	25	40	Do.
	At the anchorage in Port Blakely	43½	54½	41½	55½	Do.
	At the Saw-Mill Wharf	17	28	15	29	Do.
	In entrance to Port Orchard by Rich's Passage	54	62	52	64	U. S. Explo'g Exp., 1841.
	At the anchorage in Port Orchard under Point White	42	50	40	52	Do.
	At the anchorage under Point Turner	36	44	34	46	Do.
	In Dye's Inlet	24	32	22	34	Do.
	At anchorage in Dye's Inlet	36	44	34	46	Do.
	At anchorage in Ostrich Bay	30	38	28	40	Do.
	At anchorage under Point Belin	30	38	28	40	Do.
	At anchorage in Dog-fish Bay	42	52	40	54	Do.
	At anchorage in Yukon Harbor	39	47	37	49	Coast Survey, 1877-'78.
	Through Main Channel of Puget Sound from West Point to Point Defiance	204	215	202	218	Do.
	At anchorage on Allen Bank	60	71	58	74	Coast Survey, 1878.
	Through Colvos Passage to Point Defiance	150	162	148	163	Do.
	At anchorage under Point Peter, in Colvos Passage	36	47	34	50	Do.
	At anchorage in Trump Harbor	54	66	52	69	Coast Survey, 1877.
	At lower anchorage in Quartermaster's Harbor	45	56	43	59	Coast Survey, 1878.
	At upper anchorage in Quartermaster's Harbor	14	25	12	28	Do.
	At anchorage in Gig Harbor	30	42	28	43	Do.
	In entrance to Gig Harbor	10	22	8	23	Do.
	In entrance to Commencement Bay	540	......	......	......	Coast Survey, 1877.
	At anchorage under Point Brown	42	57	41½	58¾	Do.
	At anchorage off New Tacoma Wharves	48	63	47½	64¾	Do.
	At Coal Wharf, Tacoma	18	33	17½	34¾	Do.
	At Railroad Wharf, Tacoma	24	39	23½	40¾	Do.
	Through The Narrows to Steilacoom	160	172	158	173	Coast Survey, 1878
	At the anchorage off Steilacoom	45	57	43	58	Do.
	At Steilacoom Wharves	14	26	12	27	Do.
	Whollochet Bay anchorage	48	60	46	61	Do.
	Through Hale's Passage to Carr's Inlet	51	63	49	64	Coast Survey, 1879.
	In entrance to Carr's Inlet, between Fox and McNeill Islands	464	......	......	......	Coast Survey, 1878.
	At anchorage in Carr's Inlet, under Green Point	72	86	70	85	Coast Survey, 1879.
	At anchorage in Terrel's Cove	45	57	43	58	Do.
	At anchorage under eastern end of Raft Island	48	60	46	61	Do.

Table of depths, Pacific Coast—Continued.

WASHINGTON TERRITORY.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
PUGET SOUND and tributaries—Continued.	At anchorage off mouth of Burley Lagoon (head of inlet)	33	45	31	46	Coast Survey, 1879.
	Through Balch's Passage (between McNeill and Anderson Islands)	58½	70½	56½	71½	Do.
	Through Pitt Passage, from Balch's and Drayton's Passages to Carr's Inlet	13	25	11	26	Do.
	Through Drayton's Passage to Pitt Passage	162	174	160	175	Coast Survey, 1878.
	At the anchorage in Titusi Bay	39	51	37	52	Do.
	Through Cormorant Pass from Steilacoom to Tatsolo Point	120	132	118	135	Do.
	Through Main Channel of Puget Sound from Point Defiance to Lyle Point	160	172	158	175	Do.
	At anchorage in Oro Bay	27	39	25	42	Do.
	At anchorage off Nisqually Flats	36	48	34	51	Do.
	Through Main Channel of Sound from abreast of Lyle Point to Johnson's Point	104	117	102½	118	Do.
	Through Case's Inlet to Point Dougall	120	132	118	135	Coast Survey, 1878–'79.
	At anchorages in Case's Inlet:					
	1. Behind Herron Island	54	66	52	69	Do.
	2. In Ray's Cove	27	39	25	42	Coast Survey, 1879.
	3. Behind Stretch Island	46½	58½	44½	61½	Do.
	4. Between Stretch and Reach Islands	42	54	40	57	Do.
	5. At head of Bay	19	31½	17½	34½	Do.
	Through Pickering Passage to Peale's Passage	43	57	41	59	Do.
	Through Pickering Passage to Squaxin Passage	40½	54½	39	56½	Do.
	At the anchorage in Henderson's Inlet	30	44	28½	45	Coast Survey, 1878.
	At head of Inlet	Dry	......	......	......	Do.
	Through Dana's Passage	93	108	91	110	Coast Survey, 1879.
	Through Peale's Passage to Pickering Passage	11½	25½	9½	27½	Do.
	Through Squaxin Passage to Pickering Passage	33	47	31	49	Do.
	At the anchorage in Budd's Inlet	36	50	34	52	Coast Survey, 1873–'74.
	Up the Inlet to Olympia Wharves	½	16½	0	19½	Do.
	At the anchorage in Butler's Cove	24	38	22	40	Do.
	At the anchorage off Priest's Point	15	29	(*)	......	Do.
	At anchorage in Eld Inlet under Cooper's Point	51	65	50	66	Coast Survey, 1879.
	At upper anchorage	18	32	17	33	Do.
	In main channel of Puget Sound from Johnson's Point to Sandy Point	102	116	100	118	Do.
	At anchorage in Totten's Inlet under Sandy Point	38	52	36½	53	Do.
	At upper anchorage off Little Skookum Inlet	27	41	25½	42	Do.
	In mouth of Little Skookum Inlet	5	19	3½	20	Do.
	At anchorage in Hammersley's Inlet under Cook's Point	24	38	22½	39	Do.
	Through the Inlet to Oakland Bay	6	20	4½	21	Do.
	At anchorage in Oakland Bay	21	35	19½	36	Do.
HOOD'S CANAL and tributaries.	Up the Canal from Foulweather Bluff to Hood's Head	316½	......	......	......	Coast Survey, 1880.
	At anchorage in Port Ludlow under Tala Point	51	60	49	62	Coast Survey, 1855.
	At inner anchorage above Millport	42	51	40	53	Do.
	Entrance to Lagoon, between "The Twins"	11	20	9½	21½	Do.
	At anchorage in Lagoon	14½	23½	13	25	Do.
	Entrance to Mats-Mats	½	9½	—1	11	Do.
	At anchorage under Foulweather Bluff	72	81	70	83	Coast Survey, 1880.
	At anchorage in Hood's Head Cove	8	17	6	19	Do.
	Up the Canal from Hood's Head to Hazel Point	172½	......	......	......	Do.

* Not sufficient data.

Table of depths, Pacific Coast—Continued.

WASHINGTON TERRITORY AND BRITISH COLUMBIA.

Places.	Limits between which depths are given	Least water in channel. Mean. Lower low water.	Least water in channel. Mean. High water.	Least water in channel. Spring tides at moon's greatest declination. Lower low water.	Least water in channel. Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
HOOD'S CANAL and tributaries—Continued.	At anchorage in Squamish Harbor:					
	1. Eastern side of Middle Ground	42	51	40	53	Coast Survey, 1880.
	2. Western side of Middle Ground	39	48	37	50	Do.
	3. Above the Middle Ground	33	42	31	44	Do.
	In entrance to Port Gamble	21	30	19	32	Do.
	At anchorage south of Mill Wharf	25½	34½	23½	36½	Do.
	At anchorage off Upper Timber Wharf	18	27½	16	30	Do.
	To Head of Harbor	25½	34½	24	37	Do.
	Up the Canal from Hazel Point to Neelim Point	324	(*)	...	...	U. S. Expl'g Exp., 1841.
	At anchorage in Seabeck Harbor	54	(*)	...	...	Do.
	At anchorage in Tzusated Cove	36	(*)	...	...	Do.
	At anchorage in Hoetzen Harbor	54	(*)	...	...	Do.
	At anchorage in Quilcine Harbor	78	(*)	...	...	Do.
	At anchorage in Dabop Bay	†42	(*)	...	...	Do.
	At anchorage in Annas Bay	60	(*)	...	...	Do
	From Neelim Point to head of the Canal	24	(*)	...	...	Do
	At anchorage in Lynch Cove	21	(*)	...	...	Do.
Possession Sound and Saratoga Passage to Washington Sound.	Through Possession Sound	150	(*)	...	...	Do.
	At the anchorage in Port Gardner	39	(*)	...	...	Do.
	At the anchorage in Port Susan	42	(*)	...	...	Coast Survey, 1856.
	Through Saratoga Passage to Washington Sound (north end of Whidbey Island)	24	(*)	...	...	Do.
	At the anchorage in Holmes' Harbor	48	(*)	...	...	Do.
	At the anchorage in Penn's Cove	54	(*)	...	...	Do.
	At the anchorage in Similk Bay	15	(*)	...	...	Do.
	Through Deception Pass to Rosaris Strait	54	(*)	...	...	Do.
STRAIT OF SAN JUAN DE FUCA (North Shore).	At the anchorage in Sooke Bay	‡36	44	34	45½	U. S. Exp. Ex., 1841, and Br. Adm. Surveys.
	Over Outer Bar into Sooke Inlet	15	23	13	24½	Do.
	Over Inner Bar into "The Basin"	9	17	7	18½	Do.
	At anchorage in Sooke Basin §	48	56	46	57	Do
	At anchorage in Beecher Bay §	60	68	58	69	Do.
	Through Race Channel	66	74	64	75	Do
	At anchorage in Pedder Bay	30	38	28	39	Do.
	At anchorage in Parry Bay:					
	1. Under William Head	42	50	40	51	Do
	2. Under Albert Head	60	68	58	69	Do.
	At anchorage in Royal Bay under Albert Head	48	56	46	57	Do.
	By Fisgard Island into Esquimalt Harbor	60	68	58	69	Do.
	At anchorage in Esquimalt Harbor	36	44	34	45½	Do.
	Through Portage Inlet to Victoria	9	17	7	18½	Coast Survey, 1855.
	Through Enterprise Channel to Gonzalez Point	27	35	25	36	Do.
	Through Mayor Channel into Canal De Haro	54	62	52	63	Do.
	Through Plumper Passage into Canal de Haro	72	80	70	81	Do.
	At anchorage in Cadboro Bay	24	32	22	33	Do.
	Through Baynes Channel into Canal de Haro	30	38	28	39	Do.
WASHINGTON SOUND (Canal de Haro ‖).	In Main Entrance to Canal de Haro to Turn Point	444	(*)	...	...	Coast Sur. and Br. Adm
	From Turn Point to East Point (Gulf of Georgia)	450	(*)	...	...	Do.
	Through Western Passage, between Discovery Island and Middle Bank	240	(*)	...	...	Do.
	At the anchorage in Cormorant Bay	54	(*)	...	...	Do.
	Through Cordova Channel to abreast of north end of Sydney Island	36	(*)	...	...	Do.
	Through Sydney Channel	24	(*)	...	...	Do.

* Not sufficient data.
† At head of bay.
‡ All of these depths on North Shore subject to correction when the surveys are completed by U. S. Coast Survey.
§ Many shoals.
‖ Great care must be taken in selecting an anchorage in the Canal or the harbors that open from it.

Table of depths, Pacific Coast—Continued.

WASHINGTON TERRITORY AND BRITISH COLUMBIA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Least water in channel. Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
WASHINGTON SOUND (Canal de Haro†)—Continued.	Through Miners' Channel to Jones' Island	60	(*)			Br. Adm. and Coast Sur.
	At the anchorage in Miners' Channel	60	(*)			Do.
	Through Mosquito Passage	18	(*)			Do.
	At anchorage in Roche Harbor	48	(*)			Do.
	Through Spieden Channel from Canal de Haro to San Juan Channel	354	(*)			Do.
	Through New Channel north of Spieden Island	120	(*)			Do.
	At anchorage in Reid's Harbor (Stuart Island)	24	(*)			Do.
	Through John's Pass between John's and Stuart Islands	30	(*)			Do.
	At the anchorage in Prevost Harbor	36	(*)			Do.
	At the anchorage in Bedwell Harbor	54	(*)			Do.
	At the anchorage in Open Bight (Saturna Island)	48	(*)			Do.
	At the anchorage in Deep Cove (Saturna Island)	66	(*)			Do.
	At the anchorage under Waldron Island, between Sandy Point and Point Disney	24	(*)			Do.
	Through President Channel to Gulf of Georgia	342	(*)			Do.
	Through San Juan Channel from Strait of Fuca to Canal de Haro	‡66	(*)			Do.
	At anhcorage in Mackaye Harbor (Lopez Island)	48	(*)			Do.
	At anchorage under south shore of Griffin Bay off Hudson Bay Company's Station	78	(*)			Do.
	At anchorage in North Cove (Griffin Bay)	72	(*)			Do.
	Through Upright Channel into East Sound	144	(*)			Do.
	At anchorage in Friday Harbor	54	(*)			Do.
	Through Wasp Passage§ into Harney Channel	30	(*)			Do.
	Anchorage in West Sound (Orcas Island)	54	(*)			Do.
	Through Harney Channel into East Sound	114	(*)			Do.
	Up East Sound to its head	42	(*)			Do.
	At anchorage in East Sound	48	(*)			Do.
	At anchorage in Deer Harbor (Orcas Island)	48	(*)			Do.
	Through Spring Passage into President Channel	96	(*)			Do.
Rosario Strait	From Puget Sound, by way of Admiralty Inlet, to Watmough Head	108	(*)			Coast Survey, 1853.
	Channel between Point Partridge and Partridge Bank	108	(*)			Coast Survey, 1855.
	Channel between Partridge Bank and Smith's Island‖	210	(*)			Do.
	At the anchorage off southern side of Smith's Island	90	(*)			Coast Survey, 1854.
	At the anchorage off northern side of Smith's Island	27	(*)			Do.
	From Puget Sound, by way of Deception Island, to entrance to Rosario Strait	54	(*)			Coast Survey, 1855.
	Through the Strait of Fuca from the westward, by Main Channel, north of Smith's Island	210	(*)			Do.
	Through Rosario Strait to Gulf of Georgia:					
	1. By Main Channel under Point Lawrence and Clark's Island	150	(*)			Do.
	2. By East Channel under Lummi Island	150	(*)			Do.
	At anchorage in Watmough Bight	48	(*)			Do.
	At anchorage in Shoal Bight	48	(*)			Do.
	At anchorage in Burrows' Bay	78	(*)			Do.

* Not sufficient data.
† Great care must be taken in selecting an anchorage in the Canal or the harbors that open from it.
‡ On shoal ground abreast of Salmon Bank. Elsewhere not less than thirty fathoms. § Many rocks. ‖ Sometimes called Blunt's Island

Table of depths, Pacific Coast—Continued.

WASHINGTON TERRITORY AND BRITISH COLUMBIA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
WASHINGTON SOUND (Rosario Strait)—Continued.	In Passage between Burrows' and Allan Islands	138	(*)			Coast Survey, 1855.
	In Passage between Burrows' Island and Green Point	90	(*)			British Admiralty.
	Through Lopez Pass to Lopez Sound	30	(*)			Do.
	At anchorage in Lopez Sound	54	(*)			Do.
	Through Thatcher Pass to Lopez Sound	90	(*)			British Adm. charts.
	From Thatcher Pass through Blakely Sound to East Sound	84	(*)			Do.
	At anchorage in Blakely Sound on eastern side of Upright Point	22½	(*)			Do.
	At anchorage between Frost and Lopez Islands	78	(*)			Do.
	Through Guemes Channel into Padilla Bay	54	(*)			Do.
	At anchorage in Padilla Bay	60	(*)			Do.
	Through Padilla Bay to Bellingham Bay	60	(*)			Coast Survey, 1855.
	From Padilla Bay to Gulf of Georgia	72	(*)			Do.
	Through Bellingham Channel from Rosario Strait: 1. To Bellingham Bay	110	(*)			Do.
	2. To Gulf of Georgia	119	(*)			Do
	In Channel between Sinclair and Cypress Islands	78	(*)			Do.
	Through Bellingham Bay to anchorage off the Coal Mines	33	(*)			Do.
	At the anchorage	22½–33	(*)			Do.
	At Coal Company's Wharf	2	(*)			Do.
	At anchorage off Fort Bellingham	18	(*)			Do.
	At anchorage behind Point Frances	17	(*)			Do.
	At anchorage on northeast side of Sinclair Island	60	(*)			Do.
	At anchorage under Point William	78	(*)			Do.
	From Bellingham Bay through Hale's Passage to Sandy Point	30½	(*)			Do.
	At the anchorage under Lummi Point	36	(*)			Do.
	Channel between Lummi and Eliza Islands	84	(*)			Do.
	At anchorage under Village Point, Lummi Island	60	(*)			Do.
	Passage between Deer Point and Obstruction Island†	30	(*)			Do.
	Passage between Obstruction and Blakely Islands†	60	(*)			Do.
	In passage between Parker's Reef and Point Thompson into President Channel	46½	(*)			Do.
	In passage between Matia and Sucia Groups	378	(*)			Do.
	At anchorage under eastern shore of Sucia Islands	34½	(*)			Do.
	Passage between Sucia Islands and Parker's Reef into President's Channel	318	(*)			Do.
	Passage between Sucia and Patos Islands into Canal de Haro	222	(*)			Do.
	At anchorage off Sandy Point (Lummi Bay)	40½	(*)			Do.
(Satellite Channel)	From Canal de Haro into Satellite Channel	90	(*)			Do.
	Through Satellite Channel to Saanwich Inlet	156	(*)			Br. Adm., U. S. Exp. Ex., and U. S. Land-Office.
	Through Cowitchin Inlet‡	180	(*)			Do
	At anchorage in Cowitchin Harbor‡	36	(*)			Do
	Through Saanwich Inlet to Turn Point‡	192	(*)			Do.
	Up Finlayson arm to its head‡	54	(*)			Do.
	At anchorage in Deep Cove‡	84	(*)			Do.
	At anchorage in Union Bay‡	90	(*)			Do.

* Not sufficient data for tides.

† Many rocks.

‡ Great care should be exercised in selecting an anchorage in any of these channels.

Table of depths, Pacific Coast—Continued.

WASHINGTON TERRITORY AND BRITISH COLUMBIA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
WASHINGTON SOUND (Satellite Channel)—Cont'd.	At anchorage in Mill Creek Bay*	90	(†)	....	....	Br. Adm., U.S. Exp. Ex., and U. S. Land Office.
	At anchorage in Cole Bay*	42	(†)	....	....	Do.
	At anchorage in Tod Creek*	84	(†)	....	....	Do.
	From Cowitchin Inlet, through Sansum Narrows, into Stuart Channel*	162	(†)	....	....	Do.
	At anchorage in Fulford Harbor	60	(†)	....	....	Do.
	Passage between Moresby and Portland Islands	90	(†)	....	....	Do.
(Swanson Channel)	From Canal de Haro into Swanson Channel	600	(†)	....	....	Coast Survey, 1855.
	Through Swanson Channel to Satellite Channel*	168	(†)	....	....	Br. Adm., U.S. Exp. Ex., and U. S. Land Office.
	Through Swanson Channel to Ganges Harbor*	168	(†)	....	....	Do.
	Through Swanson Channel to Navy Channel*	294	(†)	....	....	Do.
	Through Ganges Harbor to Captain's Passage	138	(†)	....	....	Do.
	Through Captain's Passage to Trincomalee Channel	258	(†)	....	....	Do.
	At anchorage at head of Ganges Harbor	24	(†)	....	....	Do.
	At anchorage in Long Harbor	24	(†)	....	....	Do.
	At anchorage in Ellen Bay	66	(†)	....	....	Do.
	At anchorage in Otter Bay	72	(†)	....	....	Do.
(Plumper Sound)	From Canal de Haro to entrance to Plumper Sound	450	(†)	....	....	Coast Survey, 1855.
	Through Plumper Sound to Navy Channel	72	(†)	....	....	Br. Adm., U.S. Exp. Ex., and U. S. Land Office.
	Through Navy Channel to Trincomalee Channel	90	(†)	....	....	Do.
	At anchorage in Camp Bay (Pender Island)	84	(†)	....	....	Do.
	At anchorage in Port Browning (Pender Island)	36	(†)	....	....	Do.
	At anchorage in Lyall Harbor	24	(†)	....	....	Do.
	At anchorage in Horton Bay	30	(†)	....	....	Do.
(Trincomalee Channel)	From Navy Channel, through Trincomalee Channel, to Narrow Island	120	(†)	....	....	Do.
	Through Active Passage to Gulf of Georgia	96	(†)	....	....	Do.
	At anchorage in Village Bay	36	(†)	....	....	Do.
	At anchorage in Miner's Bay	66	(†)	....	....	Do.
	At anchorage in Montague Harbor	36	(†)	....	....	Do.
	In eastern entrance to Montague Harbor	42	(†)	....	....	Do.
	In western entrance to Montague Harbor	24	(†)	....	....	Do.
	Through Houston Passage from Trincomalee Channel into Stuart Channel*	102	(†)	....	....	Do.
	Through Trincomalee Channel from Narrow Island to Northumberland Channel (head of Washington Sound)*	120	(†)	....	....	Do.
	Through Portier Pass to Gulf of Georgia	60	(†)	....	....	Do.
	In passage between Indian Island and Hall Island*	150	(†)	....	....	Do.
	In passage between Hall and Reid Islands*	30	(†)	....	....	Do.
	In passage between Reid and Thetis Islands*	90	(†)	....	....	Do.
(Stuart Channel*)	At anchorage in Clam Bay	48	(†)	....	....	Do.
	Main entrance to Stuart Channel, between Yellow Point and Thetis Island	234	(†)	....	....	Do.
	Through the channel to Tent Island	276	(†)	....	....	Do.
	From abreast of Tent Island to Sansum Narrows	396	(†)	....	....	Do.
	At anchorage under northwest end of Thetis Island	48	(†)	....	....	Do.
	At anchorage in Chemainos Harbor	42	(†)	....	....	Do.
	At anchorage in Oyster Harbor	24	(†)	....	....	Do.
	At Outer Anchorage in Oyster Harbor	48	(†)	....	....	Do.

* Great care should be exercised in selecting an anchorage in any of these channels.

† Not sufficient data for tides.

Table of depths, Pacific Coast—Continued.

WASHINGTON TERRITORY AND BRITISH COLUMBIA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	Feet.	Feet.	Feet.	
WASHINGTON SOUND (Stuart Channel*)—Cont'd.	At head of Oyster Harbor	12	(†)	......	......	Br Adm., U.S. Exp. Ex., and U. S. Land Office.
	At anchorage in Preedy Harbor	42	(†)	......	......	Do.
	At anchorage in Telegraph Harbor	54	(†)	......	......	Do.
	At anchorage in Horse-Shoe Bay	48	(†)	......	......	Do.
	At anchorage in Osborn Bay	60	(†)	......	......	Do.
	At anchorage in Vesuvius Bay	72	(†)	......	......	Do.
	At anchorage in Maple Bay	90	(†)	......	......	Do.
	At anchorage in Burgoyne Bay	30	(†)	......	......	Do.
(Pylades Channel)	In entrance to Pylades Channel	102	(†)	......	......	Do.
	Through the channel to Gabriola Island	120	(†)	......	......	Do.
	Through the channel to False Narrows	30	(†)	......	......	Do.
	Through Gabriola Pass to Gulf of Georgia	30	(†)	......	......	Do.
	Through False Narrows to Northumberland Channel	2	(†)	......	......	Do.
	Through Ruxton Pass into Trincomalee Channel	36	(†)	......	......	Do.
(Northumberland Channel)	Through Dodd Narrows into Northumberland Channel	54	(†)	......	......	Do.
	Through the channel to Nanaimo Harbor	96	(†)	......	......	Do
	At anchorage under Protection Island	66	(†)	......	......	Do.
	At Outer Anchorage in Nanaimo Harbor	36	(†)	......	......	Do.
	At Upper Anchorage in Nanaimo Harbor‡	27	(†)	......	......	Do.
GULF OF GEORGIA	In entrance between Point Whitehorn and East Point	642	(†)	......	......	Br. Adm. and U. S. Exploring Expedition.
	Through the Gulf to abreast of Gabriola Island	522	(†)	......	......	Do.
	At anchorage in Birch Bay	15	(†)	......	......	Coast Survey, 1859.
	At anchorage in Semi-ah-moo Bay	40½	49½	38	50½	Coast Survey, 1857.
	At outer anchorage in Drayton Harbor	22½	32	20	32½	Do.
	At anchorage in Drayton Harbor under Drayton's Point	15	24½	12½	25	Do.
	At upper anchorage in Drayton Harbor	11	20½	8½	21	Do.
	At anchorage in Boundary Bay:					
	1. On British side	14	(†)	......	......	Coast Survey, 1858–'59.
	2. On American side	16	(†)	......	......	Do.
	Over bar into Fraser River	9	(†)	......	......	Br. Adm. and U. S. Exploring Expedition.
	From Garry Point through to Inner Bar	27	(†)	......	......	Do.
	Over Inner Bar	16	(†)	......	......	Do.
	From Inner Bar to upper end of Annacis Island	23	(†)	......	......	Do.
	Over Annacis Bar	12	(†)	......	......	Do.
	From Annacis Bar to New Westminster	31	(†)	......	......	Do.
	From the Gulf around northwest end of Gabriola Island to Nanaimo Harbor entrance	78	(†)	......	......	Do.

BRITISH COLUMBIA.

Port San Juan	At the anchorage	36	(†)	......	......	British Admiralty, 1847.
Barclay Sound	To anchorage in Bamfield Creek	36	(†)	......	......	British Admiralty, 1861.
	To Entrance Anchorage	36	(†)	......	......	Do.
	To anchorage in Kelp Bay	36	(†)	......	......	Do.
	To anchorage in Christie Bay	36	(†)	......	......	Do.
	Through Shark Pass to anchorage in Dodge's Cove	18	(†)	......	......	Do.

* Great care must be taken in selecting an anchorage in any of these channels. † Not sufficient date for tides. ‡ Many shoals.

Table of depths, Pacific Coast—Continued.

BRITISH COLUMBIA.

Places.	Limits between which depths are given.	Least water in channel.				Authorities.
		Mean.		Spring tides at moon's greatest declination.		
		Lower low water.	High water.	Lower low water.	Higher high water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Barclay Sound—Continued	Through Harbor entrance to anchorage in Island Harbor	66*				Br. Admiralty, 1861.
	Through Southern Entrance to anchorage in Island Harbor	54*				Do.
	To anchorage in Toquart Harbor through David Channel	84*				Do.
	To anchorage in Ucluelet Arm	30*				Do.
	To anchorage in Schooner Cove	12*				Do.
Clayoquot Sound	Through Main Ship Channel to anchorage in Ritchie Bay	30*				Do.
	To anchorage in Warn Bay	30*				Do.
	To anchorage in Bawden Bay	24*				Do.
Hesquiat Harbor	To anchorage at Head of Harbor	24*				Do.
Nootka Sound	Entering through Zuciarte Channel to anchorage in Head Bay	90*				Do.
	To anchorage in Friendly Cove	30*				Do.
Esperanza Inlet	To anchorage in Rolling Roads	30*				Br. Admiralty, 1863.
	Through Birthday Channel to anchorage in Port Eliza	60*				Do.
Kyuoquot Sound	To anchorage in Kok-Shittle Arm	60*				Do.
	To anchorage in Easy Creek	54*				Do.
	To anchorage in Table Island Harbor through Schooner Entrance	24*				Do. Do.
	Through Halibut Channel to anchorage in Clanninick Harbor	36*				Do.
On-On-Kinsh Inlet	To anchorage in Battle Bay	36*				Do.
Nasparte Inlet	To anchorage at head of Inlet	78*				Do.
Klaskish Inlet	To anchorage under Shelter Island	48*				Do.
Klaskino Inlet	To anchorage under Anchorage Island	54*				Do.
Quotsino Sound	Through the Eastern Entrance to anchorage in Koprino Harbor	42*				Br. Admiralty, 1862.
	Through Western Passage to anchorage in Koprino Harbor	72*				Do.
	To anchorage in North Harbor	24*				Do.
San Josef Bay	To anchorage	24*				Br. Admiralty, 1860.
Goletas Channel	To anchorage in Bull Harbor	27*				Do.
	To anchorage in Shushartie Bay	66*				Do.
Smith's Sound	To anchorage in Takusk Harbor	42*				Br. Admiralty, 1872.
Fitz Hugh Sound	Through Verney Passage to anchorage in Schooners' Retreat	42*				Br. Admiralty, 1867-'70
	To anchorage in Safety Cove	90*				Do.
Hecate Island	To anchorage in Goldstream Harbor	36*				Do.
	To anchorage in Welcome Harbor	42*				Do.
Milbank Sound	To anchorage in Saint John Harbor	42*				Do.
	Through Mathieson Channel to anchorage in Port Blakeney	66*				Do.
Principe Channel	To anchorage in Port Stephens	90*				Do.
	To anchorage in Port Canaveral	84*				Do.
Chatham Sound	To anchorage in Refuge Bay	42*				Do.
	To anchorage in Metlah Catlah Bay	19½*				Do.
	To anchorage in Duncan Bay	42*				Do.
	To anchorage in Big Bay	66*				Do.
	At Qlawdzeet Anchorage (north shore of Stephens Island)	60*				Do.

*** Not sufficient data for tides.**

Table of depths, Pacific Coast—Continued.

BRITISH COLUMBIA AND ALASKA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Chatham Sound—Continued	To anchorage in Pearl Harbor	60*				Br. Admiralty, 1867-'70.
	At Otter Anchorage	96*				Do.
	Through Dodd Passage to anchorage in Port Simpson	48*				Do.
	Through Inskip Passage to anchorage in Port Simpson	48*				Do.
ALASKA.						
DIXON ENTRANCE (Channels and adjacent Harbors.)	Passage through Lincoln Channel	7½*				Russian Surveys and U. S. Coast Survey, 1867.
	Anchorages off Fort Tongas:					
	1. Anchorage in Southeast Entrance	144*				Do.
	2. Approach to Mid-channel Anchorage	24*				Do.
	3. At anchorage in Mid-channel	120*				Do.
	In entrance to Tlehonsiti Harbor from the westward	36*				Do.
	To the anchorage in Tlehonsiti Harbor	36*				Do.
	To anchorage in Tlehonsiti Harbor abreast of Fort Tongas	210*				Do.
	To anchorage in the Middle Kai-gah-nee Harbor	45*				Etolin, 1833.
	To anchorage in American Bay (Howkan Strait)	66	78†			Coast Survey, 1881.
	To anchorage off Howkan Village	39	51†			Do.
	To anchorage in Prisoner's Cove	30*				Etolin, 1833.
Portland Canal	To anchorage in Naas Bay	60*				Br. Admiralty Chart.
	To anchorage in Iceberg Bay	48*				Do.
	To anchorage in Salmon Cove	186*				Vancouver, 1798.
Revillagigedo Channel	To anchorage in Ward Cove	60*				Coast Survey, 1881.
Clarence Strait	To anchorage in Tamgas Harbor	72*				Etolin, 1833.
	To anchorage in Kasa-an Bay	30*				Coast Survey, 1880.
Behm Canal	At anchorages in Port Stewart:					
	1. In entrance to Inner Anchorage	30*				Vancouver, 1798.
	2. At Inner Anchorage	36*				Do.
	3. At Outer Anchorage	90*				Do.
Zimovia Strait	To anchorage off Point Highfield	54*				Br. Admiralty Chart.
	To anchorage in Etolin Harbor	48*				Coast Survey, 1869.
Sumner Strait	To anchorage in Port Protection	96*				Vancouver, 1798.
Wrangell Strait	At Half Moon Anchorage	30*				U. S. Hyd. Office.
	Through the Strait from southward to Hood's Point	22½	38½†			Coast Survey, 1881.
	From abreast of Hood's Point through The Narrows	15	31†			Do.
	From The Narrows to Rock Point	19½	35½†			Do.
	From Rock Point through to Frederick Strait	19½	35½†			Do.
Frederick Sound	To anchorage in Woewodsky Harbor	27*				Zaremba, 1838.
	To anchorage in Security Roads	72*				U. S. Hyd. Office.
	To anchorage in Snug Harbor	42*				Do.
Stephens Passage	To anchorage in Taku Harbor	60*				Do.
	To anchorage in Juneau Harbor (Gastineau Channel)	96	114†			Coast Survey, 1881.
	To anchorage in Fritz Cove	78	96†			Do.
CHATHAM STRAIT and Lynn Canal	To anchorage in Port Malmesbury	72*				Vancouver, 1798.
	In entrance to Alexander Bay	24*				Do.
	At anchorage in Alexander Bay	36*				Do.
	To anchorage in Port Conclusion	42*				Do.
	To anchorage in Ship Cove	30*				Do.

* Not sufficient data for tides. † Approximate mean rise and fall given.

Table of depths, Pacific Coast—Continued.

ALASKA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	High water.	Spring tides at moon's greatest declination. Lower low water.	Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
CHATHAM STRAIT and Lynn Canal—Continued.	In entrance to Port Armstrong	36*				Vancouver, 1798.
	At anchorage in Port Armstrong	42*				Do.
	In entrance to Security Bay	84	98†			Coast Survey, 1881.
	At anchorage in Security Bay	72–100	86†–114†			Do.
	At anchorage in White Water Bay	84	100†			Do.
	At anchorage in Kootsnoo Roads:					
	1. Outer Anchorage	90*				U. S. Hyd. Office.
	2. Anchorage off the Village	72*				Do.
	To anchorage in Lindenburg Harbor (Peril Strait)	114*				Coast Survey, 1869.
	To anchorage in Schulze Cove (Peril Strait)	42*				U. S. Hyd. Office.
	At Favorite Anchorage (Peril Strait)	18*				Do.
	At anchorage in Wachusett Cove (Freshwater Bay)	48	66†			Coast Survey, 1881.
	At anchorage in I'youk-een Cove	138*				Coast Survey, 1869.
	To anchorage in Koteosok Harbor	42*				U. S. Hyd. Office.
	In the approach to Stillwater Anchorage	30*				Do.
	At anchorage	102*				Do.
	To anchorage in Pavloff Harbor	90*				Do.
	To anchorage in William Henry Bay	72*				Do.
	To anchorage in Pyramid Island Harbor	102*				Do.
	To anchorage in Portage Bay	54*				Do.
COAST FROM DIXON ENTRANCE TO CAPE SPENCER.	In entrance to Port Bazan	42*				Tebenkoff, 1849.
	At Outer Anchorage	90*				Do.
Port Bazan	To Inner Anchorage	102*				Do.
Port Bucareli	To anchorage in Calder Bay	30*				Caamano, 1792.
	To anchorage in Dolores Bay	42*				Do.
	To anchorage in Santa Cruz Bay	36*				Do.
	To anchorage in San Antonio Bay	90*				Do.
	To anchorage in Asuncion Bay	60*				Do.
Puffin Bay	In entrance	24*				Russian-Amer. Co., 1849.
	At anchorage	42*				Do.
Whale Bay	In entrance to Closed Bay	48*				Tebenkoff, 1849.
	At anchorage in Closed Bay	102*				Do.
Spruce Island Anchorage	In entrance	21*				Old Russian Chart.
	At the anchorage	15*				Do.
SITKA SOUND‡ and Anchorages.	Hot Springs Bay Anchorage	21*				Do.
	Symonds Bay Anchorage	30	39†			Coast Survey, 1881.
	At Eastern Anchorage (Whiting Harbor)	48	57†			Do.
	At Western Anchorage (Whiting Harbor)	36	45†			Do.
	To anchorage in Cross Harbor	42*				Tebenkoff, 1849.
	At anchorage in Jamestown Bay	30–42	39–51†			Coast Survey, 1881.
	In entrance to Sitka Harbor from westward:					
	1. North of Channel Rock	51	60†			Do.
	2. Between Channel Rock and Battery Island (Main Channel)	51	60†			Do.
	At Outer Anchorage	39	48†			Do.
	Over bar abreast of Harbor Island	21	30†			Do.
	At anchorage off Sitka	36–60	45–69†			Do.
	At Government Wharf	18	27†			Do.
	At wharf at eastern end of Japonski Island	18	27†			Do.
	In entrance to Sitka Harbor from eastward:					
	1. East of Rocky Patch	126	135†			Do.
	2. West of Rocky Patch	120	129†			Do.
	At Outer Anchorage off Kutkan Island	88	97†			Do.
	Through The Narrows between Harbor Island and Government Wharf	36	45†			Do.

* Not sufficient data for tides. † Approximate mean rise and fall given. ‡ Surveyed by Commander Beardslee, U. S. N.

Table of depths, Pacific Coast—Continued.

ALASKA.

Places	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
SITKA SOUND; and Anchorages—Continued.	At the usual anchorage off Sitka	36	45†			Coast Survey, 1881.
	In entrance to Sitka Harbor through the Middle Channel	36*	45†			Do.
	To anchorage in Hunting Bay	120*				Russian Adm. Charts.
	In entrance to Harbor on Kruzoff Island	42*				Do.
	At anchorage in Harbor on Kruzoff Island	90*				Do.
	To anchorage in Port Mary	36*				Do.
	To anchorage in Kalinina Bay	24*				Do.
	To anchorage in Ilina Bay	54*				Old Russian Chart
Cross Sound and Icy Strait	To anchorage in Swanson's Harbor	36*				U. S. Hyd. Office.
	To anchorage in Spaskaia Bay	24*				Bubnoff.
	To anchorage in Hoonyah Harbor	60*				Lieut. Symonds, U.S.N
	To anchorage in Willoughby Cove	48*				U. S. Hyd. Office.
	To anchorage in Granite Cove	108*				Coast Survey, 1880
	To anchorage in Port Althorp	72*				Do.
COAST FROM CAPE SPENCER TO PRINCE WILLIAM SOUND.	In entrance to Lituya Bay	27	33†			Coast Survey, 1874
	At anchorage off Astronomical Station	30	36†			Do.
	Up the bay to Cenotaph Island	90*				La Perouse.
	Passage to westward of Cenotaph Island	120*				Do.
Yakutat Bay	In entrance to Port Mulgrave	42	50†			Coast Survey, 1874.
	At the anchorage	57	65†			Do.
	In entrance to New Russia Harbor	36*				Old Russian Chart.
	At the anchorage	18*				Do.
Middleton Island	At the anchorage under western side of the Island	66*				Coast Survey, 1874.
Prince William Sound (Harbors and Anchorages).	To anchorage in Port Etches	36*				British Adm. Charts.
	Over bar into Constantine Harbor	15*				Do.
	To the anchorage, from inside the bar	18*				Do.
	To the anchorage in Garden Cove	30*				Do.
	To the anchorage in Snug Corner Cove	42*				Cook, 1778.
	To the anchorage in Chalmers Harbor	54*				Vancouver, 1798.
Cook's Inlet (Harbors and Anchorages).	To anchorage in Port Chatham	60*				Do.
	To anchorages in Port Graham‡:					
	1. In Coal Bay	54*				Russ. Surveys & Coast Survey, 1880
	2. In middle of English Harbor	78*				Do.
	3. At head of English Harbor	72*				Do.
	To anchorage in Cheslokna Bay	42*				Do.
	Kachekmak Bay:					
	1. To anchorage in Kahsitsnah Bay	82*				Do.
	2. At anchorage under Coal Point	36*				Do.
	To anchorage in Ugolnoi Bay	48*				W. U. Tel. Co's. Exp
	To anchorage off Fort Kenai	5*				Tebenkoff, 1849.
Kadiak Island and Harbors	To anchorage in mouth of Afognak River	72				Russian Adm. Chart
	In entrance to Brick-yard Harbor	18*				Old Russian Chart XVI
	At anchorage in Brick-yard Harbor	66*				Do.
	Entrance to Saint Paul Harbor:					
	1. Through the North Channel	132*				Do.
	2. By the South Channel	96*				Do.
	At Outer Anchorage off Chagafka Cove	78*				Coast Survey, 1874.
	At anchorage at entrance to Inner Harbor	54*				Old Russian Chart XVI
	At Inner Anchorage off the Village	36*				Do.
	To Inner Anchorage	30*				Do.
	At anchorage in Winter Harbor	24*				Do.
	To anchorage in Middle Bay	30*				Do.
	Kalsinskia Gulf, anchorage in	72*				Do.
	To anchorage in Ugak Bay	210*				Russian Adm. Charts

* Not sufficient data for tides. † Approximate mean rise and fall given. ‡ Surveyed by Commander Beardslee, U. S. N.

Table of depths, Pacific Coast—Continued.

ALASKA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Least water in channel. Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Kadiak Island and Harbors—Continued.	To anchorage in Kiliuda Bay	48*				Russian Adm. Charts.
	At anchorage in Bay of Three Saints	84*				Old Russian Chart.
	In entrance to Bay of Three Saints	36*				Do.
	To anchorage in Uyak Bay	162*				Tebenkoff, 1849.
Chirikoff Island (Shumagin Group).	To Southwest Anchorage	39	44†			Coast Survey, 1875.
Big Koniushi Island	At anchorage in Yukon Harbor	39	45†			Do.
Little Koniushi Island	At anchorage in Northwest Harbor	30	36†			Do.
	At anchorage in Northeast Harbor	48	54†			Coast Survey, 1872
Simeonoff Island	In entrance to Simeonoff Harbor	24*				Do.
	At anchorage in Simeonoff Harbor	18*				Do.
Nagai Island and Harbors	In entrance to Falmouth Harbor	36*				Do.
	At anchorage in Falmouth Harbor	42*				Do.
	In entrance to Eagle Harbor	24*				Do.
	At anchorage in Eagle Harbor	42*				Do.
	At anchorage in Sanborn Harbor	78	82†			Do.
	In entrance to Porpoise Harbor	9	13†			Do.
	At anchorage in Porpoise Harbor	24	28†			Do.
Unga Island and Harbors	To anchorage in Delaroff Harbor	18*				Russian Admiralty.
	To anchorage in Humboldt Harbor	42	48†			Coast Survey, 1872.
	Through Popoff Strait to Korovin Strait	42	49†			Do.
	Through Zachareffskaia Bay to Coal Harbor	48*				
	To anchorage in Zachareffskaia Bay	36*				
	In entrance to Coal Harbor:					
	1. North of Round Island	42	46†			Do.
	2. South of Round Island	27	31†			Do.
	At anchorage in Coal Harbor	36	40†			Do.
Unga Strait and Harbors	Through Unga Strait	240*				Russian Surveys.
	At anchorage in Portage Bay	42*				Do.
	In entrance to Beaver Bay	48*				Do.
	At anchorage in Beaver Bay	78*				Do.
Sannakh Islands	At anchorage in Acherk Harbor	24*				Do.
ALIASKA PENINSULA and **Harbors.**	At anchorage in Coal Bay	42*				Do.
	At anchorage in Chignik Bay	42*				Coast Survey, 1874.
	At anchorage on NE. side of Chiachi Island	48*				Do.
	At anchorage in Kukak Bay	60*				Vasilie[illegible] 1831.
	At anchorage in Katmai Bay	48*				Russi[illegible] Admiralty.
	At anchorage in Port Wrangell	54*				Vasil[illegible]ff, 1832.
	At anchorage in Kupreanoff Harbor	84*				Voro[illegible]koffski, 1837.
	At anchorage in Belkoffski Bay	120*				Coa[illegible] Survey, 1880.
	At outer anchorage in Bailey's Harbor	60*				U.[illegible]Rev. Marine, 1879.
	At inner anchorage in Bailey's Harbor	42*				Do.
	At anchorage between Deer and Fox Islands	36*				[illegible]ssian Surveys.
	In entrance to Morzhoovi Bay	60*				Do.
	In entrance to Issannakh Strait	105*				Do.
	At anchorage in Saint Catherine's Cove	24*				Do.
Akutan Island	To anchorage in Chin-Chan Bay	54*				Tebenkoff, 1849.
UNALASHKA ISLAND and **Harbors.**	At anchorage in Dutch Harbor	102*				Coast Survey, 1874.
	In entrance to Iliuliuk Harbor:					
	1. Through the North Channel	19½	23½†			Coast Survey, 1871–'72
	2. Through the South Channel	30	34†			Do.
	At anchorage in Iliuliuk Outer Harbor	84	88†			Do.
	At anchorage in Iliuliuk Inner Harbor	60	64†			Do.
	At anchorage to southward of Expedition Island	39	43†			Do.
	At Iliuliuk Wharf	7½	11½†			Do.
	In entrance to Port Levasheff	60	64†			Coast Survey, 1872.

* Not sufficient data for tides. † Approxima[illegible] mean rise and fall given.

Table of depths, Pacific Coast—Continued.

ALASKA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
UNALASHKA ISLAND and Harbors—Continued.	Passage from Iliuliuk Harbor to Port Levasheff	24	28†			Coast Survey, 1872.
	At anchorage in Port Levasheff	36	40†			Do.
	At anchorage under Eider Point	126*				Coast Survey, 1874.
	To anchorage in Makushin Bay	36*				Saricheff, 1792.
	To anchorage in Kah-she-ga Bay	36*				Do.
	In entrance to Chernoffsky Bay	102*				Do.
	At anchorage in Chernoffsky Bay	78*				Do.
	In entrance to Kuliliak Bay	66*				Do.
	At anchorage in Kuliliak Bay	36*				Do.
	At anchorage in Udamat Bay	54*				Do.
	At anchorage in Ugalek Bay	84*				Do.
	At anchorage in Udagak Strait	102*				Do.
	To anchorage in Kisselen Bay	72*				Do.
	To anchorage in Ke-ka-kalen Bay	138*				Do.
	To anchorage in Agamguk Bay	30*				Do.
	In entrance to Samganuda Bay	120*				Cook, 1778.
	At anchorage in Samganuda Bay	42*				Do.
Amlia Island	In entrance to Sviechnikoff Harbor	108*				Tebenkoff, 1849.
	At the anchorage	48*				Do.
Atka Island and Harbors	To anchorage in Nazan Bay	72*				Do.
	To inner anchorage in Korovinski Bay	6*				Do.
	To outer anchorage in Korovinski Bay	66*				Do.
	To anchorage in Sandy Bay	36*				Do.
	To anchorage in Saranna Bay	18*				Do.
Adakh Island and Harbors (Aleutians).	In Northern Entrance to Bay of Islands	30*				Coast Survey, 1873.
	In Northwestern Entrance to Bay of Islands	54*				Do.
	In Western Entrance to Bay of Islands	96*				Do.
	At anchorage in Bay of Islands	84*				Do.
	At anchorage in Bay of Waterfalls	42*				U. S. Pac. Sur. Ex., 1855.
	At anchorage in Tanaga Bay	60*				Saricheff, 1792.
Amchitka Island (Aleutians)	At anchorage in Constantine Harbor	48–66*				Coast Survey, 1873.
Attu Island	To anchorage in Massacre Harbor	12*				Bielieff.
	Over Bar in Chichagoff Entrance	19½*				U. S. Pac. Sur. Ex., 1855.
	At the anchorage in Chichagoff Harbor	30*				Do.
	In entrance to Port Möller	54*				Russian Surveys.
	At anchorage in Port Möller	60*				Do.
Great Kyska Island (Aleutians)	To anchorage in Kyska Harbor	36	40½†			Coast Survey, 1873.
	To anchorage on southern shore of harbor	43½	48†			Do.
Bristol Bay and Harbors (Bering Sea).	To anchorage in Mouth of Ugazhak River	12*				Tebenkoff, 1849.
	To anchorage in Mouth of Ugiagik River	24*				Do.
	To anchorage in Mouth of Naknek River	12*				Do.
	To anchorage in Nushegak River, one mile from Fort Alexander	12*				Bryant, 1869.
Kulukak Bay (Bering Sea)	To anchorage in bay	18*				Tebenkoff, 1849.
	To anchorage W. of Hagenmeister Island	48*				Do.
Pribiloff Islands	At anchorage in Southwest Bay (Saint George)	90*				Coast Survey, 1874.
	At anchorage in Garden Cove (Saint George)	54*				Do.
	At Northern Anchorage (Saint George)	102*				Do.
	At anchorage W. of Reef Point (Saint Paul)	42*				Do.
	At anchorage E. of Reef Point (Saint Paul)	48*				Do.
	At anchorage S. of Sea-lion Point (Saint Paul)	48*				Do.
	At anchorage W. of Northeast Point (Saint Paul)	30*				Do.
Good News Bay (east coast Bering Sea).	In entrance to bay	21*				Tebenkoff, 1849.
	At the anchorage	12*				Do.

* Not sufficient data for tides. † Approximate mean rise and fall given.

Table of depths, Pacific and Arctic Coasts.

ALASKA AND ASIA.

Places.	Limits between which depths are given.	Least water in channel. Mean. Lower low water.	Mean. High water.	Spring tides at moon's greatest declination. Lower low water.	Spring tides at moon's greatest declination. Higher high water.	Authorities
		Feet.	Feet.	Feet.	Feet.	
Nunivak Island (east coast Bering Sea).	At anchorage under Cape Etolin	36*				Coast Survey, 1874.
	At anchorage N. of Cape Vasilieff	48*				Tebenkoff, 1849.
	At anchorage E. of Cape Ignatieff	72*				Do.
Saint Matthew Island (Bering Sea).	At anchorage southwest of Cape Upright	138*				U. S. N., U. S. Rev. Mar., 1874 & Coast Sur., 1880
	At anchorage northwest of Cape Upright	54*				Do.
Hall Island	At anchorage southeast of North Cape	114*				U. S. N., U. S. Revenue Marine, 1874.
Norton Sound and Harbors (east coast Bering Sea).	To anchorage east of Stewart Island	18*				Tebenkoff, 1849.
	To anchorage abreast of Fort Saint Michaels	18*				Do.
	To anchorage in Golofnin Bay	42*				Do.
	To anchorage east of Aziak or Sledge Island	18*				Do.
Port Clarence (Bering Strait)	To anchorage in Port Clarence	30-42*				Coast Survey, 1880.

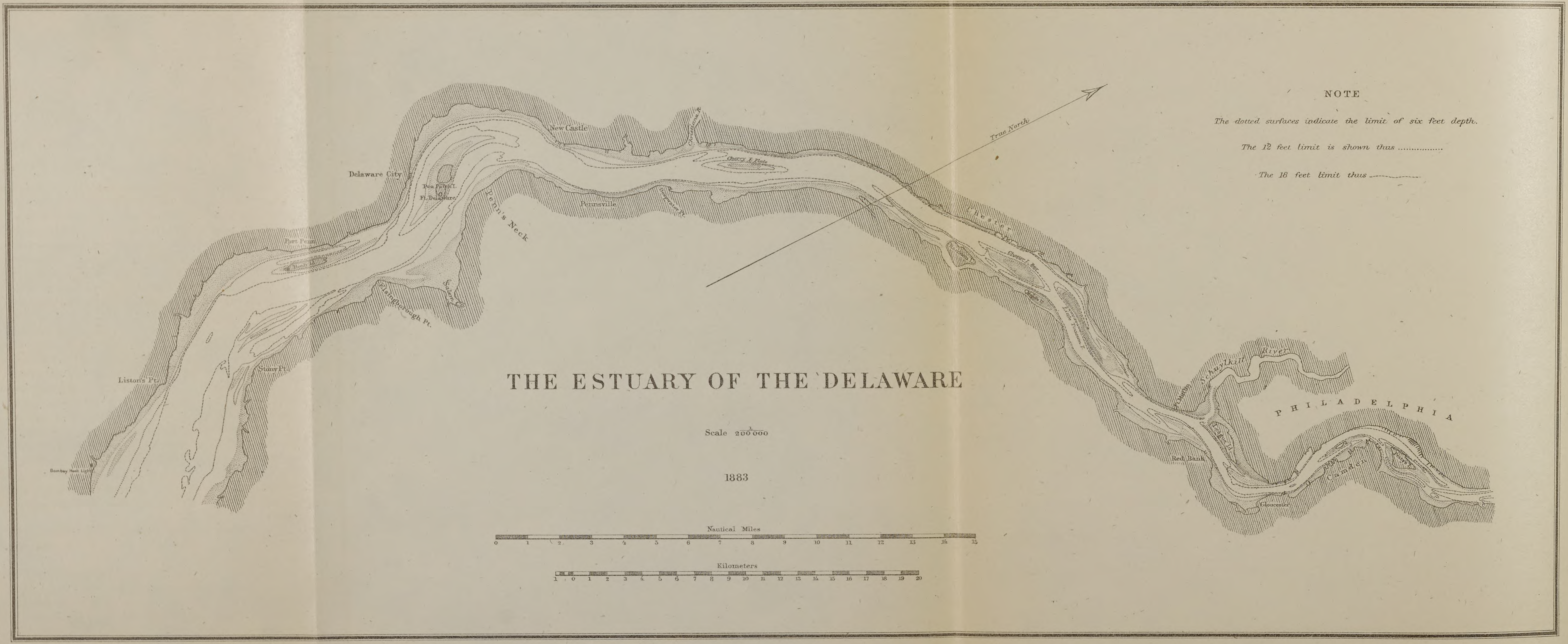
PACIFIC AND ARCTIC COASTS OF ALASKA AND ASIA.

Places.	Limits between which depths are given.	Lower low water.	High water.	Lower low water.	Higher high water.	Authorities
Grantley Harbor (Bering Strait)	In entrance to harbor	13½*				Beechy, 1827.
	At the anchorage	18*				Do.
Kotzebue Sound (Arctic Ocean)	To anchorage under Chamisso Island	36*				Do.
	To anchorage under Choris Peninsula	30*				Do.
Point Hope (Arctic Coast)	At anchorage to the southward of the Point	54*				British Admiralty.
	At anchorage to the northward of the Point	54*				Do.
Cape Lisburne (Arctic Coast)	At anchorage to the eastward of the Cape	36*				Do.
Point Barrow (Arctic Coast)	At anchorage under the Point	24*				Do.
Port Moore (Arctic Coast)	In entrance to Port Moore	42*				Do.
	At the anchorage	15*				Do.

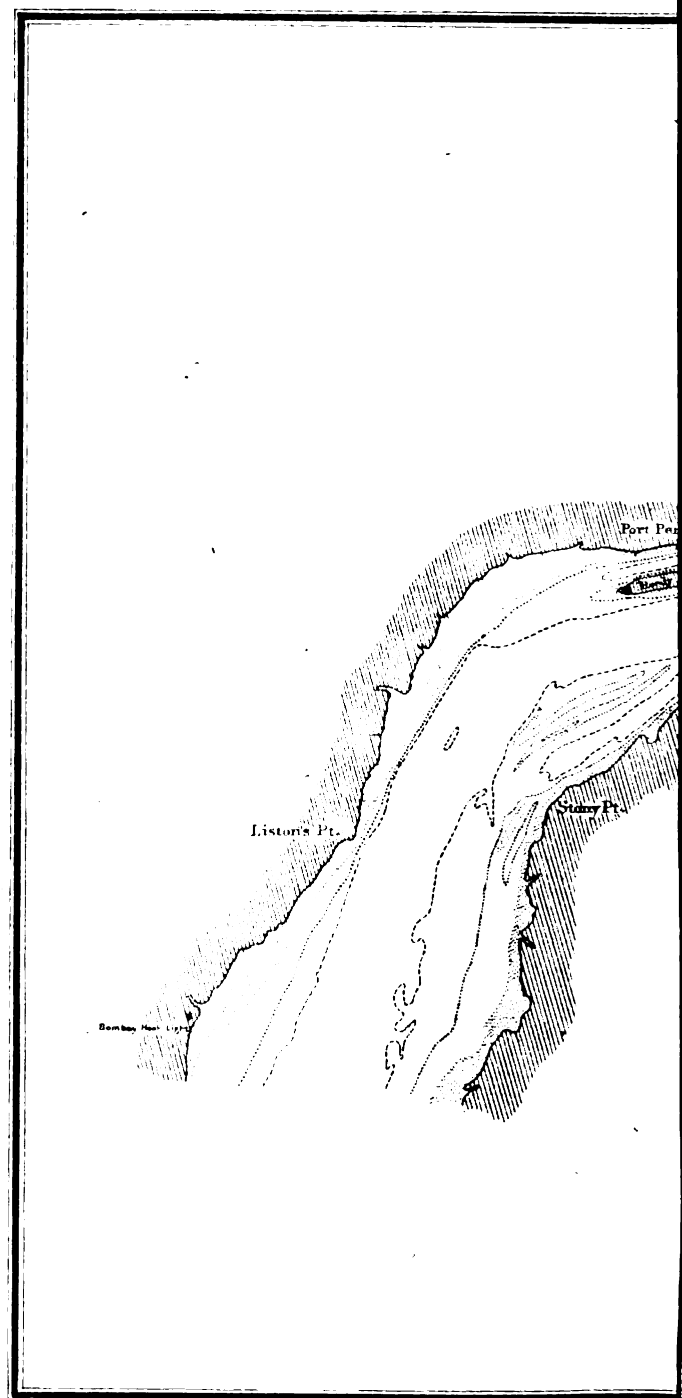
EASTERN COAST OF ASIA.

Places.	Limits between which depths are given.	Lower low water.	High water.	Lower low water.	Higher high water.	Authorities
Saint Lawrence Bay (Bering Strait).	In entrance to the bay	60*				U. S. Hydrog. Office.
	At the anchorage behind Lutke Island	72*				Onatsevich, 1877.
	At the anchorage near Middle of Bay	30*				Do.
	At the anchorage at Head of Bay	18*				Do.
Mechigme Bay (Bering Strait)	In entrance to the bay	54*				Tebenkoff, 1849.
	At the anchorage	36*				Do.
Seniavine Strait	To anchorage in Ratmanoff Harbor	27*				U. S. Hydrog. Office
	To anchorage at head of Alera Bay	42*				Do.
	To anchorage in Penkegu Bay	36*				Lutke, 1828.
	To anchorage in Abolecheff Bay	60*				U. S. Hydrog. Office
	To anchorage in Glazenapp Harbor	114*				Do.
Port Providence	At anchorage in Plover Bay	108*				Onatsevich, 1877.
	At anchorage in Slavianka Harbor	78*				Do.
	At anchorage in Emma Harbor	45*				Coast Survey, 1869
	To anchorage at head of Cache Bay	24*				Do.
	To anchorage in Snug Harbor	42*				Do.

* Not sufficient data for tides.


THE ESTUARY OF THE DELAWARE
Scale $\frac{1}{200\,000}$
1883
NOTE
The dotted surfaces indicate the limit of six feet depth.
The 12 feet limit is shown thus ....
The 18 feet limit thus ----------
True North
Nautical Miles
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Kilometers
1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
New Castle
Delaware City
Pea Patch I.
Ft. Delaware
Penn's Neck
Pennsville
Cherry I. Flats
Port Penn
Liston's Pt.
Stony Pt.
Chester
Schuylkill River
PHILADELPHIA
Red Bank
Gloucester
Camden

No. 25



APPENDIX No. 8.

THE ESTUARY OF THE DELAWARE.

A report by HENRY MITCHELL, Assistant.

In a report made in March, 1881, which was published as Appendix No. 13 of the Annual Report of the Coast and Geodetic Survey for 1879, I called your attention to three rules which answer well for over 60 miles of the Delaware below League Island. These rules are:

"1st. The transverse section is directly proportional to the discharge.

"2d. The width is proportional to the discharge.

"3d. The mean-depth is the same in all sections."

These rules were based upon surveys made forty years ago, and I dared not, therefore, employ the data except in large groups, not only because I doubted the accuracy of the field-work, but also because the soundings did not cover the ground uniformly, so that discrepancies were found to exist among smaller groups.

I have now in my hands the portion of the new survey from Philadelphia to a point 52 miles below. This portion I shall call the *estuary* for distinction, because below this we come upon a submerged delta where the stream splits into numerous channels not unlike the passes of the Mississippi, or more like those of the Ganges after its issue upon the Bay of Bengal.

In my earlier work my data were grouped for reaches of 5 miles each, but in my work upon the new survey I have increased the number of my groups by diminishing the distance covered by each group to one nautical mile. This I have done at some risk of discord arising from *bend effects*. The bends in the course of a stream flowing through alluvium cause deepening at the apices and corresponding shoaling at reversions. This was found to be true in the Lower Mississippi, both as regards mean-depth and channel-depth. The widths are also similarly affected. In order, therefore, to obtain the broadest view of the river's dimensions, each group of data should be large enough to include at least one bend and one inflection, or equal multiples of similar bends and inflections. Practically this can only be realized in large groups, where inequalities of reverse curvatures disappear.

Nevertheless, with this new survey in my hands, as perfect in its details as I could ask, I have felt that I could afford to let occasional contradictions go uncancelled, rather than lose the benefit of *number* in evidence.

At the close of this report the compiled data are furnished for the estuary of the Delaware from 734 cross sections with widths varying from 1 to 5 miles and including many thousand soundings. It was a vast work to compile accurately so many measures of width and depth, and compute the area of every section separately; but happily you had assigned for this work one whose long experience as Assistant upon the Coast and Geodetic Survey rendered him a judge and an expert in such matters. Mr. J. A. Sullivan, the person to whom I refer, has seen no occasion to reject any observed data, and he has, at my request, prefaced his tables by notes upon his method, which materially add to the strength of the testimony. These notes and a statement of the data consulted appear at the end of this paper.

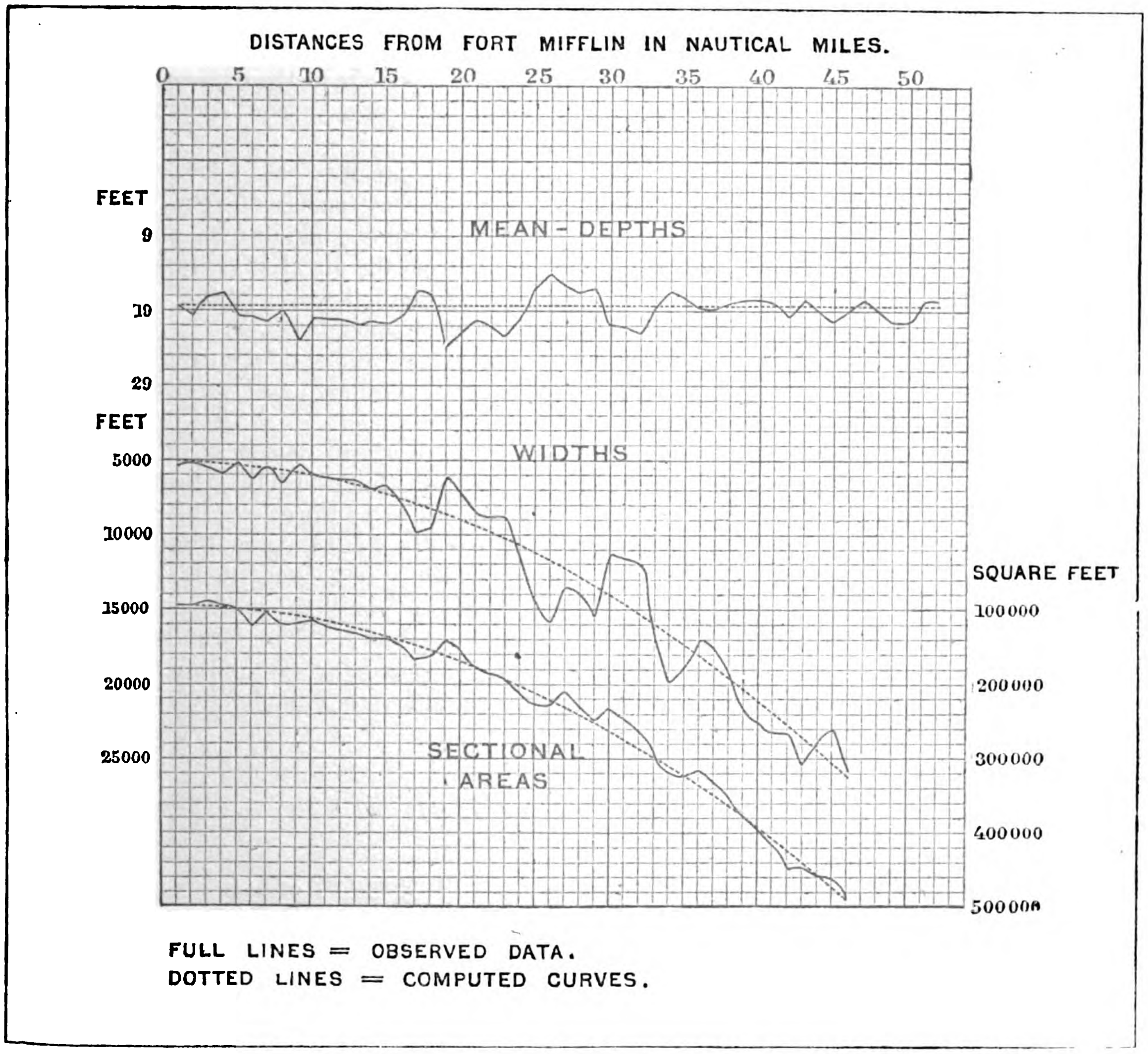
In a table and diagram that immediately follow I reproduce some of the data to which I have referred, and add some computed curves generalizing the results.

Estuary of the Delaware, half-tide dimensions.

x Distance in nautical miles from Fort Mifflin Light.	Observed mean-depth in feet.	Mean-width.		Mean-area of section.	
		Observed feet.	$10.1x^2 + 5,100$.	Observed. square feet.	$188x^2 + 95,000$.
1	18	5, 300	5, 100	95, 400	95, 000
2	19. 4	5, 000	5, 100	97, 000	95, 000
3	17. 0	5, 400	5, 200	91, 800	96, 000
4	16. 7	5, 900	5, 300	98, 500	98, 000
5	19. 6	5, 000	5, 400	98, 000	100, 000
6	19. 5	6, 400	5, 500	124, 000	102, 000
7	20. 1	5, 300	5, 600	106, 500	104, 000
8	18. 5	6, 500	5, 700	120, 200	106, 000
9	23. 0	5, 200	5, 900	119, 600	109, 000
10	19. 8	5, 900	6, 100	116, 800	114, 000
11	19. 6	6, 200	6, 300	121, 500	118, 000
12	20. 1	6, 400	6, 600	128, 600	121, 000
13	20. 8	6, 400	6, 800	133, 100	127, 000
14	20. 1	7, 000	7, 100	140, 700	132, 000
15	20. 8	6, 700	7, 400	139, 400	137, 000
16	19. 7	7, 700	7, 700	151, 800	143, 000
17	16. 7	9, 900	8, 000	165, 000	149, 000
18	17. 1	9, 500	8, 400	162, 000	156, 000
19	24. 1	6, 000	8, 700	144, 000	163, 000
20	21. 7	7, 200	9, 100	156, 000	170, 000
21	20. 37	8, 600	9, 630	175, 000	178, 000
22	21. 05	8, 700	10, 000	183, 000	186, 000
23	22. 31	8, 700	10, 400	194, 000	194, 000
24	19. 22	11, 200	10, 900	215, 000	205, 000
25	15. 85	14, 600	11, 400	231, 000	213, 000
26	14. 54	15, 900	11, 900	232, 000	222, 000
27	15. 78	13, 400	12, 500	211, 000	232, 000
28	16. 51	13, 900	13, 000	230, 000	242, 000
29	15. 95	15, 500	13, 600	247, 000	253, 000
30	20. 92	11, 300	14, 200	236, 000	264, 000
31	21. 18	11, 700	14, 800	248, 000	276, 000
32	21. 88	12, 100	15, 400	264, 000	288, 000
33	18. 01	16, 800	16, 100	302, 000	300, 000
34	16. 28	19, 900	16, 800	325, 000	312, 000
35	17. 20	18, 800	17, 500	322, 000	325, 000
36	18. 86	16, 800	18, 200	317, 000	339, 000
37	18. 94	17, 500	18, 900	332, 000	352, 000
38	18. 28	19, 700	19, 700	360, 000	366, 000
39	17. 59	21, 700	20, 500	381, 000	381, 000
40	17. 50	22, 700	21, 300	398, 000	396, 000
41	17. 98	23, 200	22, 100	417, 000	411, 000
42	19. 30	23, 400	22, 900	452, 000	427, 000
43	17. 65	25, 400	23, 800	449, 000	443, 000
44	19. 42	23, 600	24, 700	458, 000	459, 000
45	20. 17	23, 000	25, 600	464, 000	476, 000
46	19. 17	25, 700	26, 500	493, 000	493, 000
47	17. 72	....	....	....	....
48	19. 32	....	....	....	....
49	20. 57	....	....	....	....
50	20. 25	....	....	....	....
51	18. 00	....	....	....	....
52	17. 62	....	....	....	....

The point of greatest interest and physical importance is the ***constancy of mean-depth.*** In the first figure of the diagram (p. 241), which represents the mean-depth for each nautical mile, any one must admit, I think, that a horizontal straight line best represents the generalized result, there being no order of recurrence in the fluctuations above and below.

These fluctuations in the mean-depth are mostly due to inequalities in the nature of the soil. At Deep-water Point (nineteenth mile of our table), for instance, gravel and stones brought down by the ice, perhaps, have held the bank against the stream, while in other places the soft banks have sloughed away under the action of waves. These peculiar sections might have been rejected as anomalous, but I have preferred to accept all the testimony precisely as furnished by the surveyors, letting the stony points and sloughing banks offset each other, which they do very well. Some of the smaller fluctuations are, no doubt, due to uncancelled *bend effects*. The grand mean, including all the soundings for 46 nautical miles, is 18.64 feet.



The *width* of the estuary must, however, be regarded as the independent variable of our table, and for this reason the equation of a curve which should sweep out its irregularities has been sought, with a view to using it as a factor in generalizing the variations of sectional areas. Happily a very simple expression was found to answer, viz: *the square of the distance in nautical miles multiplied by* 10.1, and this multiplied again by 18.64 (the constant of mean-depth) is the curve of sectional areas.

These curves, I submit, are just as real in nature as the constant of mean-depth. No ingenuity has been employed, and the harmony of these expressions with fundamental laws of motion simply indicates that running water has adjusted its bed to its own demands, for the tide is the working agent here.

Under the parabolic expression for the increments of width that has been given, the increments of surface area should follow the third power of the distance, and the rule of the former report, "*width proportional to discharge,*" could not hold good were it not that the range of the tide declines with distance (at first in a marked degree and then slightly, as indicated by the observations of the United States Engineers), so that to obtain the increments of discharge we should not multiply the areas by a constant, but by a diminishing quantity.

It will be observed that the ratio of perimeter to sectional area remains essentially the same throughout the estuary; I do not, however, regard this as a primary condition making my rule for discharge possible, but as a resultant. Tidal streams, augmenting their discharge as they approach the sea, must necessarily make their deposits so as to form shallow and divergent estuaries, for there is no disposition to deepen if there is no restraint at the sides; but the contrary, as when a stream issues upon the sea, or a lake, it widens at the expense of its depth of flow. In the estuary of the Delaware we have a remarkable case of equilibrium resulting in a constancy of *mean-depth.*

Of course it may be safely inferred from our rule that the mean velocities for our cross-sections are the same, but we have no observations upon the transverse curves of velocities from which to predict the drift through the ship channel. The importance of making such observations you have already seen, and I need not remind you that, aside from the direct advantage to the navigator from the better tables we shall be able to furnish, we shall discover in the profiles of these curves the changes that induce or reflect the variations of channel depth.

I have spoken of the adjustment of the mold of the estuary to the tidal currents; but I hasten to say that in this adjustment cause and effect are convertible terms. The *reaction* of the bed and banks is measured in the retard of the *tide-wave.*

The remarkable uniformity of mean depth, and the recurrent sameness of channel depth for the 46 miles under consideration should lead us to expect that the tidal retardation, so far as affected by depth, should also be uniform, and this appears to be the case. But the formula for the times of high water given in a former report (Appendix No. 18, Annual Report Coast and Geodetic Survey, 1881) contains two terms, one of which may be regarded as reflecting the uniform resistance of the bed, while the other indicates a continual increment of resistance, which I submit is due to the converging width of the estuary. The formula referred to is $y = 2.2x + 0.018x^2$, which gives almost exactly, in minutes, the delay of the tide from the breakwater (from which the distance x is measured in nautical miles) to Philadelphia, as shown in the subjoined table, quoted from the former report:

Progress of the tide in Delaware Bay and River.

Number of data.	Distances in nautical miles.	Localities.	Observed time of high water.	Curve by formula.	Difference of observed and computed times.	Observed time of low water.	Curve by formula.	Difference of observed and computed times.
			Minutes.		*Minutes.*	*Minutes.*		*Minutes.*
659	0	Breakwater	0	0	....	0	0	....
20	42.1	Collins' Beach	125	124½	0½	167	175	8
28	49.4	Port Penn	151	152½	1½	210	212	2
17	54.2	Fort Delaware	171	172	1	237	237	0
21	58.9	New Castle	191	192	1	264	262 7/10	1½
21	61.9	Pigeon Point	206	205	1	285	279 4/10	5½
127	64.7	Edgemoor	216	217½	1½	297	295	2
109	70.4	Marcus Hook	243	244	1	330	328 9/10	1½
6	73.7	Chester	259	260	1	350	348	2
88	79.0	Billingsport	284	286	2	378	381	3
104	80.9	Fort Mifflin	296	295 8/10	0	391	393	2
23	92.1	Five-mile Point	356	355	1	461	465 8/10	5
13	112.4	Bordentown	483	474 7/10	8½	605	609½	4½

In the above table there also appear the times of low-water for which the formula was

$$y^1 = 3.4x + 0.018x^2$$

in which the uniform resistance dependent upon depth has increased its coefficient with the fall of the tide, while the second term has remained unchanged, because the width has declined very little, comparatively, and this without altering the law of its variation.

We may, at the expense of simplicity and extent of application, introduce the width instead of the distance into this second term of the tidal formula. If we transfer the origin from the Breakwater to Fort Mifflin, and measure the distances and times in the opposite direction, the expression for high water becomes $5.11x-0.018x^2$; and now introducing instead of x^2 its value from the width formula $(10.1x^2+5100)$ we have, strictly within our limits—

5.11 *distance* — 0.0018 *width* + 92 *minutes*. In this form each term has its distinct physical meaning, which was not the case before.

I think this is the first instance where uniformity of depth has afforded the opportunity to measure the distinct influence of *width* upon the tidal propagation in a funnel-shaped avenue.

It remains to show what practical value these inquiries may have—not because their intrinsic interest would not have justified the time and labor given to them, but because they were undertaken with practical purposes in view.

This persistent tendency to constancy of mean-depth throughout the whole length of the estuary would seem to discourage the hope of improvement by dredging. There is a spell upon the scene which must be broken if permanent increase of depth over the bars is demanded by commerce. Except for two or three shallow reaches of short extent, there is plenty of water from the ocean to Philadelphia, and at these obstructed reaches artificial contractions of the water-way may be made without altering the course of the stream or sensibly reducing the tidal volume; so that deepening may be induced where required without changing the conditions elsewhere.

The advantage of dredging over indirect methods lies, of course, in the confinement of the expenditure to the *channel*. The method by contraction induces scour over the whole section in about the proportion of depth, and the work done by this means elsewhere than in the ship channel is of little or no benefit. The economic question, however, is—which will give the best result?

The diagonal bars at the nodes of reverse curves in the course of the river may be obliterated by contraction, and the channel *centralized*. This is an important economical consideration, because wherever we find a single midway channel the width affects the depth proportionally for every ordinate of the profile. If, for instance, the cross-section is a parabola (and this it often is), reduction of the surface chord induces 50 per cent. more deepening in the channel than in the mean-depth. Comparisons between mean-depth and channel-depth for the estuary of the Delaware show that the maximum depth in the cross-section is 1.84 times the mean-depth—of course, in these comparisons the *bend effects* for reverse curves do not cancel. In our mile groups there are only eight where this ratio sinks below 1.50, and none below 1.40.

This is as far as my province extends into engineering.

November 1, 1883.

Very respectfully yours,

HENRY MITCHELL,
Assistant.

Mr. J. E. HILGARD,
Superintendent Coast and Geodetic Survey.

The *resumé* of computations furnished in the subjoined table is based upon the following hydrographical sheets, viz:

Fort Mifflin to Tinicum Island, 1881, 1–5000. H. L. Marindin, Assistant.
Tinicum Island to Chester Island Bar, 1881, 1–5000. Lieut. H. B. Mansfield, U. S. N.
Chester Island Bar to Raccoon Creek, 1881, 1–5000. Lieut. H. B. Mansfield, U. S. N.
Raccoon Creek to Old Man's Creek, 1881, 1–5000. H. L. Marindin, Assistant.
Old Man's Creek to Penn's Grove, 1881, 1–5000. H. L. Marindin, Assistant.

Penn's Grove to Deep Water Point, 1881, 1–5000. Lieut. H. B. Mansfield, U. S. N.
Deep Water Point to New Castle, 1881, 1–5000. H. L. Marindin, Assistant.
New Castle to Reedy Point, 1881, 1–10000. Lieut. H. B. Mansfield, U. S. N.
Reedy Point to Reedy Island light-house, 1881, 1–10000. H. L. Marindin, Assistant.
Reedy Island light-house to Collins' Beach, 1881, 1–10000. Lieut. H. B. Mansfield, U. S. N.
Collins' Beach to Bombay Hook, 1882, 1–10000. H. L. Marindin, Assistant.
Arnold's Point to Cohansey light-house, 1882, 1–10000. Lieut. H. B. Mansfield, U. S. N.
Bombay Hook to Mahon's Ditch, 1882, 1–20000. H. L. Marindin, Assistant.
Main Ship Channel from Cohansey light-house to Mahon's River light-house and approaches to Cohansey Creek, 1880, 1–20000. Lieut. E. B. Thomas, U. S. N.

The lines of soundings upon these sheets were made from shore to shore, at distances apart in mid-river of about 280 feet where the survey was upon the scale of 1–5000; 550 feet upon 1–10000; 870 feet upon 1–20000; and in general were at right angles to the axis of the stream. In exceptional cases, where the bends in the river were sharp, the lines did not represent always the shorter distance from shore to shore, through slight irregularity in divergence, while still maintaining very closely their relative position in the middle of the river. The average number of lines of soundings per nautical mile was 21 where the survey was on the scale of 1–5000, 11 on 1–10000, 7 on 1–20000; the twenty-third mile, where the scales of 1–5000 and 1–10000 joined, having 16 lines.

In computing the mean depth from these surveys, a paper scale was applied to each cross-sectional line of soundings, beginning at low-water line on the right bank, and a depth read at each 200 feet throughout the 734 sections from Fort Mifflin to about the end of the forty-sixth mile, opposite Cohansey light-house. The sum of the depths thus obtained in a cross-section, minus half the sum of the first and last reading at an even space, was multiplied by 200 and divided by the width of the section. In case of a fractional distance at the end of a line the area of the fractional section was computed, and its area and length added to that of the previous spaces. From Cohansey light-house to Mahon's Ditch, that is, from the seven hundred and thirty-fifth to the seven hundred and seventy-fifth section, inclusively, where the survey was upon the scale of 1–20000, 400 feet spaces were used in computing the sections.

In a few cases the lines of soundings on either side of an island were not coincident. In obtaining a cross-section in these places the scale was extended across the sheet from one of the lines and the proportional depths used between adjacent lines of soundings on the prolongation.

The half-tide area of cross-section was found by adding to the low-water area of the section the low-water width, multiplied by 3 feet, the half range of tide. To this sum was added the widths between low water and the 3-foot elevation multiplied by $\frac{3}{2}$. The 3-foot elevation is not designated always on the chart. In these cases the approximate half-tide width beyond the low-water line was obtained by using half the distance from low water to high water where the high-water line has been designated by recent surveys, and where the new topographical survey is not completed, an estimate of the strand was made from general knowledge of the shore line as defined by previous surveys.

Beginning at Fort Mifflin light-house a mid-stream line was drawn upon the charts, upon which the river was divided into nautical miles of 6,076 feet.

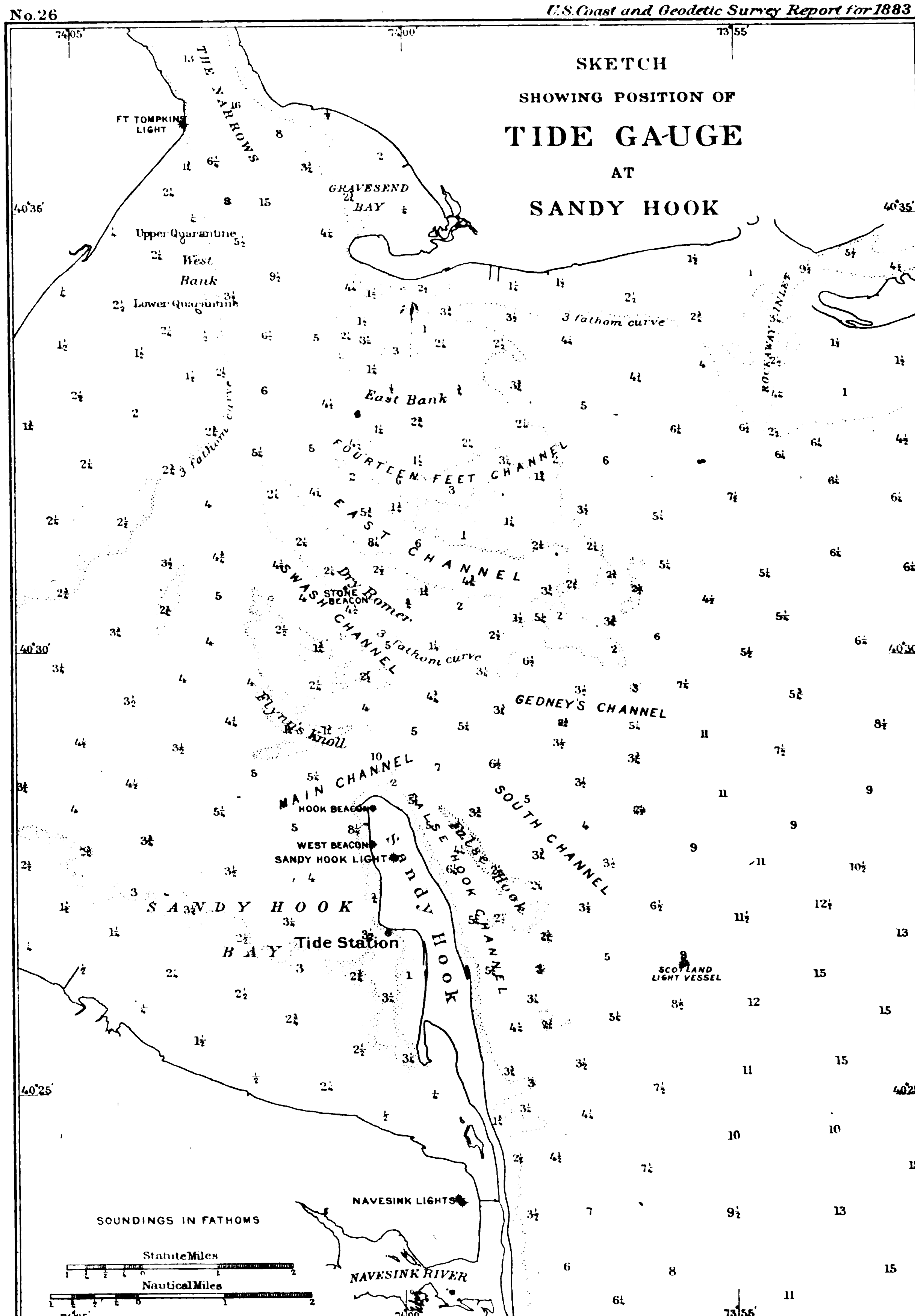
The mean depth of each nautical mile was obtained by dividing the arithmetical mean of the areas of the cross-sections in each mile by the arithmetical mean of the widths of these sections. The last cross-section in each mile group was used as the first cross-section in the next mile group.

From the extreme accuracy with which the bed of the river is developed by this survey any but a slight or proportional variation in the area or depth of adjacent sections attracted attention, and such variation was found on re-examination of the section upon the chart to be due to some obvious natural peculiarity, either in the banks or the bed of the river.

J. A. S.

Estuary of the Delaware.

Nautical miles from Ft. Mifflin Light.	No. of sections per mile.	Low water.			Half tide.			Mean channel depth per mile at low water.	Remarks.
		Mean width per mile.	Mean area per mile.	Mean depth per mile.	Mean width per mile.	Mean area per mile.	Mean depth per mile.		
		Feet.	*Square feet.*	*Feet.*	*Feet.*	*Square feet.*	*Feet.*	*Feet.*	
1	20	5, 026. 50	80, 676. 80	16. 05	5, 341. 00	96, 228. 05	18. 02	33. 6	
2	24	4, 615. 00	83, 845. 81	18. 17	5, 075. 10	98, 380. 97	19. 39	27. 5	Maiden Island.
3	26	4, 977. 31	78, 761. 26	15. 82	5, 586. 44	94, 606, 88	16. 94	43. 7	Upper end Tinicum Island.
4	19	5, 247. 63	85, 661. 20	16. 32	6, 144. 42	102, 749. 28	16. 72	37. 4	
5	23	4, 726. 09	89, 427. 97	18. 92	5, 334. 78	104, 519. 27	19. 59	30. 7	
6	23	5, 369. 57	99, 634. 05	18. 56	5, 996. 24	116, 682. 76	19. 46	32. 2	Lower end Tinicum Island.
7	21	4, 675. 95	95, 456. 28	20. 42	5, 407. 38	110, 581. 27	20. 43	40. 7	Chester Island Bar begins.
8	22	5, 686. 82	101, 449. 43	17. 84	6, 503. 41	119, 743. 77	18. 41	34. 5	Chester Island Bar ends.
9	22	4, 777. 27	104, 012. 57	21. 77	5, 177. 27	118, 944. 39	22. 98	30. 7	Schooner Ledge.
10	22	5, 513. 64	99, 761. 50	18. 09	6, 131. 36	117, 229. 00	19. 12	25. 5	
11	23	5, 817. 83	102, 553. 15	17. 63	6, 432. 17	120, 928. 15	18. 81	26. 6	
12	22	5, 915. 91	109, 503. 39	18. 51	6, 502. 05	128, 130. 32	19. 71	28. 5	
13	23	5, 911. 74	115, 110. 43	19. 47	6, 341. 30	133, 490. 00	21. 05	26. 9	
14	22	6, 515. 45	120, 126, 86	18. 44	7, 018. 64	140, 474. 36	20. 01	25. 9	
15	20	6, 244. 50	119, 295. 28	19. 10	6, 624. 50	138, 598. 78	20. 92	26. 8	
16	20	7, 278. 00	129. 549. 95	17. 80	7, 557, 50	151, 803. 20	20. 09	26. 8	
17	21	9, 656. 19	136, 725. 76	14. 16	10, 143. 33	166, 425. 05	16. 47	25. 1	
18	21	8, 604. 76	136, 032. 95	15. 81	9, 211. 43	162, 757. 24	17. 67	25. 0	Christiana Creek.
19	22	5, 652. 27	127, 867. 73	22. 62	6, 414. 09	145, 967. 27	22. 76	42. 4	Deep Water Point.
20	20	6, 273. 00	136, 908. 00	21. 82	7, 072. 25	156, 925. 87	22. 19	41. 2	
21	20	8, 203. 50	150, 090. 85	18. 30	8, 606. 00	175, 305. 10	20. 37	30. 4	
22	22	8, 090. 91	158, 676. 61	19. 61	8, 514. 55	183, 584. 80	21. 56	27. 9	
23	16	8, 363. 13	167, 726. 34	20. 06	8, 651. 87	193, 248. 84	22. 34	31. 2	
24	11	10, 868. 18	182, 036. 82	16. 75	11, 195. 45	215, 132. 27	19. 22	27. 7	
25	13	14, 193. 08	188, 694. 31	13. 29	14, 486. 92	231, 714. 31	15. 99	30. 6	
26	11	14, 707. 27	185, 766. 36	12 63	15, 500. 00	231, 077. 27	14. 91	36. 9	Fort Delaware Island begins.
27	12	11, 566. 67	173, 368. 42	14. 99	12, 833. 33	209, 968. 42	16. 36	38. 9	Fort Delaware Island ends.
28	12	13, 576. 67	188, 430. 29	13. 88	13, 881. 67	229, 617. 79	16. 54	29. 0	
29	14	15, 122. 86	201, 425. 36	13. 32	15, 457. 14	247, 295. 36	16. 00	26. 1	
30	13	10. 923, 08	202, 626. 38	18. 55	11, 327. 69	236, 002. 54	20. 83	41. 5	
31	12	11, 440. 83	213, 694. 71	18. 68	11, 811. 67	248, 657. 46	21. 05	48. 5	Reedy Island begins.
32	13	11, 619. 23	227, 727. 92	19. 60	12, 149. 23	263, 380. 62	21. 68	37. 2	
33	13	16, 295. 38	251, 776. 73	15. 45	16, 767. 69	301, 386. 35	17. 97	24. 8	Reedy Island ends.
34	12	19, 549. 58	265, 433. 00	13. 58	19, 949. 58	324, 681. 75	16. 28	23. 8	
35	12	18, 307. 08	266, 314. 71	14. 55	18, 707. 08	321, 835. 96	17. 20	23. 2	
36	12	16, 421. 67	267, 409. 75	16. 28	16, 821. 67	317, 274. 75	18. 86	26. 8	
37	13	17, 106. 92	279, 638. 31	16. 35	17, 506. 92	331, 559. 08	18. 94	27. 8	
38	13	19, 313. 85	301, 862. 92	15. 63	19, 713. 85	360, 404. 46	18. 28	26. 1	
39	13	21, 269. 23	316, 901. 31	14. 90	21, 669. 23	381, 309. 00	17. 60	23. 2	Collins' Beach.
40	13	22, 346. 15	330, 403. 85	14. 79	22, 746. 15	398, 042. 31	17. 50	23. 9	
41	13	22, 784. 62	347, 881. 54	15. 27	23, 184. 62	416, 835. 38	17. 98	27. 6	
42	12	23, 033. 33	382, 503. 33	16. 61	23, 433. 33	452, 203. 33	19. 30	30. 3	
43	11	25, 032. 73	373, 298. 45	14. 91	25, 432. 73	448, 996. 64	17. 65	30. 1	
44	13	23, 153. 85	387, 284. 46	16. 73	23, 553. 85	457, 346. 01	19. 42	34. 0	
45	13	22, 582. 31	395, 178. 69	17. 50	22, 982. 31	463, 525. 62	20. 17	38. 8	Bombay Hook.
46	13	25, 313. 85	416, 380. 08	16. 45	25, 713. 85	492, 921. 62	19. 17	40. 4	Cohansey Light-House.
		11, 949. 38	195, 106. 34	17. 08	12, 448. 11	231, 705. 93	19. 00	31. 3	Arithmetical mean of 46 miles.
			16. 33	....	....	18. 61	....	....	Mean from mean area of 46 miles divided by mean width of 46 miles.
47	8	33, 400. 00	493, 048. 75	14. 91	33, 800. 00	598, 848. 75	17, 72	42. 0	
48	8	32, 037. 50	530, 118. 75	16. 55	32, 437. 50	626, 831, 25	19. 32	41. 7	
49	7	31, 471. 40	560, 520. 00	17. 81	31, 871. 40	655, 534. 29	20. 57	41. 7	
50	8	35, 212. 50	610, 938. 75	17. 35	35, 612. 50	717, 176. 25	20. 11	46. 6	
51	7	46, 600. 00	699, 402. 86	15. 01	47, 000. 00	839, 802. 86	17. 87	47. 1	
52	7	52, 157. 10	768, 792. 86	14. 74	52, 557. 14	925, 864. 28	17. 62	50. 5	Mahon's Ditch.
		15, 010. 57	243, 129. 11	16. 97	15, 497. 91	288, 894, 82	18. 98	32. 8	Arithmetical mean of 52 miles.
			16. 20	....	....	18. 64	....	....	Mean from mean area of 52 miles divided by mean width of 52 miles.


SKETCH
SHOWING POSITION OF
TIDE GAUGE
AT
SANDY HOOK
FT TOMPKINS LIGHT
THE NARROWS
GRAVESEND BAY
Upper Quarantine
West Bank
Lower Quarantine
ROCKAWAY INLET
3 fathom curve
East Bank
FOURTEEN FEET CHANNEL
EAST CHANNEL
SWASH CHANNEL
Dry Romer
STONE BEACON
GEDNEY'S CHANNEL
Flynn's Knoll
MAIN CHANNEL
SOUTH CHANNEL
HOOK BEACON
WEST BEACON
SANDY HOOK LIGHT
False Hook
FALSE HOOK CHANNEL
Sandy Hook
SANDY HOOK BAY
Tide Station
SCOTLAND LIGHT VESSEL
NAVESINK LIGHTS
NAVESINK RIVER
SOUNDINGS IN FATHOMS
Statute Miles
Nautical Miles
74°05'
74°00'
73°55'
40°35'
40°30'
40°25'

Appendix No. 9.

REPORT ON THE HARMONIC ANALYSIS OF THE TIDES AT SANDY HOOK.

WASHINGTON, D. C., *July* 31, 1883.

SIR: I have the honor to submit to you the following report on the harmonic analysis of the hourly co-ordinates of the heights of the tide at Sandy Hook for the years 1876–1881, inclusive. The situation of the tide-station, with regard to the entrance to New York Harbor and the hydrography of the vicinity are best understood from the accompanying chart. The hourly co-ordinates were measured off from the curves of the self-registering tide-gauge in the tidal division of the office and furnished to me by Mr. R. S. Avery, the chief of the division.

The method of analysis is precisely the same as that adopted heretofore, a full account of which is given in my report on the Discussion of Tides in Penobscot Bay, contained in Appendix No. 11, report for 1878. Everything having been there given in detail with regard to methods, formulæ, and auxiliary tables used in the reductions, illustrative examples, &c., it will be unnecessary to go over the whole ground again here; and for these things references will simply be made to that report. It will therefore only be necessary to give in this paper the constants for the several tide components for each of the several years, together with a few theoretical deductions from them, interesting in connection with the general theory of the tides and useful in explaining any local peculiarity in the type of the tide at the station and the cause of its variation from that of tides at other stations.

The comparison of the constants for each of the several years gives a very good idea of the probable errors of the constants deduced from one year's hourly co-ordinates. From this it will be seen that a long series of observations, or of hourly co-ordinates measured from the curves, is not necessary to obtain the constants with sufficient accuracy for practical purposes. The constants here given, with certain reductions of the epochs to adapt them to any given year, will serve for all future time in the prediction of the tides for the station, either by computation or by means of the tide-machine, which, for this purpose, must be set in accordance with these constants.

I have the honor to be, very respectfully, yours,

WILLIAM FERREL.

Prof. J. E. HILGARD,
Superintendent United States Coast and Geodetic Survey.

RESULTS OF THE HARMONIC ANALYSIS OF THE TIDES AT SANDY HOOK.

The following are the amplitudes and epochs of the tide-components at Sandy Hook, with all the usual reductions applied. With these reductions the constants should be the same for each year, and hence the results of the several years are comparable.

M-TIDE.

	1876.	1877.	1878.	1879.	1880.	1881.	Mean.
$A_1 =$	.013	.027	.032	.042	.026	.016	.026
$\varepsilon_1 =$	107°	8°	347°	25°	356°	228°	
$A_2 =$	2.238	2.230	2.272	2.244	2.229	2.250	2.246
$\varepsilon_2 =$	217°.0	218°.0	217°.8	217°.5	215°.3	216°.3	217°.0
$A_3 =$	.025	.022	.021	.035	.029	.030	.027
$\varepsilon_3 =$	191°	196°	202°	192°	222°	206°	201°.5
$A_4 =$	.020	.016	.017	.020	.024	.027	.021
$\varepsilon_4 =$	349°	339°	336°	321°	335°	329°	335°
$A_6 =$	.049	.048	.053	.046	.057	.059	.052
$\varepsilon_6 =$	352°	355°	351°	344°	344°	342°	348°

S-TIDE.

A_1 =	.026	.028	.028	.025	.036	.049	.032
ϵ_1 =	225°	222°	254°	216°	255°	237°	235°
A_2 =	.439	.432	.436	.445	.416	.435	.434
ϵ_2 =	246°.0	244°.5	248°.0	245°.4	242°.1	249°.4	245°.9
A_3 =	.051	.047	.049	.050	.037	.045	.047
ϵ_3 =	79°	72°	74°	88°	72°	36°	76°
A_4 =	.036	.047	.033	.033	.037	.041	.038
ϵ_4 =	65°	64°	83°	81°	68°	52°	69°

K-TIDE.

A_1 =	.322	.330	.340	.337	.333	.342	.334
ϵ_1 =	91°.0	91°.2	89°.6	91°.4	87°.8	89°.5	90°.1
A_2 =	.129	.126	.113	.114	.130	.160	.129
ϵ_2 =	45°.3	34°.2	30°.2	39°.8	34°.9	40°.2	37°.4

L-TIDE.

A_2 =	.103	.110	.108	.084	.075	.072	.092
ϵ_2 =	51°.5	46°.5	29°.5	34°.9	0°.0	21°.3	30°.5

N-TIDE.

A_2 =	.470	.507	.532	.500	.457	.475	.490
ϵ_2 =	197°.7	195°.5	198°.9	202°.1	199°.3	198°.9	198°.7

O-TIDE.

A_1 =	.178	.167	.163	.157	.177	.176	.170
ϵ_1 =	93°.5	95°.3	98°.6	101°.4	90°.1	100°.3	96°.5

P-TIDE.

A_1 =	.103	.123	.091	.100	.102	.100	.103
ϵ_1 =	97°.3	102°.0	103°.0	106°.9	105°.7	107°.7	103°.8

μ-TIDE.

A_2 =	.072	.063	.094	.061	.083	.039	.069
ϵ_2 =	221°	216°	235°	207°	249°	236°	227°

λ-TIDE.

A_2 =	.012	.039	.030	.029	.042	.062	.036
ϵ_2 =	15°	26°	26°	69°	60°	13°	35°

ν-TIDE.

A_2 =	.045	.124	.167	.153	.065	.077	.105
ϵ_2 =	178°	238°	198°	170°	149°	253°	198°

R-TIDE.

A_2 =	.020	.030	.010	.011	.073	.037	.030
ϵ_2 =	324°	241°	19°	16°	318°	9°	334°

T-TIDE.

A_2 =	.098	.105	.046	.075	.111	.058
ϵ_2 =	116°	34°	306°	155°	94°	23°

J-TIDE.

	1876.	1877.	1878.	1879.	1880.	1881.	Mean.
$A_1=$	.013	.024	.014	.014	.009	.025	.016
$\varepsilon_1=$	86°	125°	145°	111°	107°	134°	118°

Q-TIDE.

	1876.	1877.	1878.	1879.	1880.	1881.	Mean.
$A_1=$	.039	.039	.029	.033	.033	.037	.035
$\varepsilon_1=$	118°	131°	107°	133°	98°	134°	120°

MS-TIDE (shallow water).

	1876.	1877.	1878.	1879.	1880.	1881.	Mean.
$A_2=$	.045	.037	.050	.039	.041	.040	.042
$\varepsilon_2=$	116°	122°	107°	116°	104°	114°	113°

2 SM-TIDE (shallow water).

	1876.	1877.	1878.	1879.	1880.	1881.	Mean.
$A_2=$	.018	.014	.007	.021	.010	.005	
$\varepsilon_2=$	138°	158°	66°	237°	338°	323°	

ANNUAL INEQUALITY (meteorological).

	1876.	1877.	1878.	1879.	1880.	1881.	Mean.
$A_1=$	.083	.066	.066	.072	.060	.058	.068
$\varepsilon_1=$	224°	225°	164°	203°	236°	198°	208°

MS-TIDE (fortnightly).

	1876.	1877.	1878.	1879.	1880.	1881.	Mean.
$A_1=$	.030	.014	.010	.042	.011	.014	
$\varepsilon_1=$	41°	171°	332°	224°	230°	23°	

The range of the whole tide at Sandy Hook being small, the most of the preceding results are of little importance practically, or even in the study of the theoretical relations. The analysis, however, has been carried regularly through all the components for each of the six years. It will hardly be worth while to do this hereafter in any of the small-range tides along the coast south of Cape Cod on to the Gulf of Mexico.

The first component of the mean lunar or M-tide is a true theoretical tide, but so small that it has been only imperfectly brought out in the analysis, as the scattering values of the epochs ε_1 for the several years indicate. The mean amplitude is only about one-third of an inch. The next one, of which the amplitude is A_2, is the mean lunar tidal component, and is the principal one of all. The mean amplitude, 2.246 feet, is almost precisely the same as was obtained for Governor's Island from the discussion of the tides there by the old methods. The greatest difference between this and the amplitudes deduced for each year is only .026 of a foot, or 0.3 of an inch. Hence either one of these amplitudes is sufficiently accurate for practical purposes. The epochs ε_2 are also brought out with great regularity. The other components of this tide are shallow-water components, and are very small and of no importance practically, though they are clearly brought out in the analysis, as the epochs, agreeing so nearly for so small components, indicate.

The mean solar or S-tide is very small, not only absolutely, but relatively to the mean lunar tide, the amplitude A_2 of the principal component being less than one-fifth of that of the mean lunar tide. This is a peculiarity which is found along our whole Atlantic coast. The small component in the S-tide of which the amplitude is A_1, is a real component, and is well brought out in the analysis, as the nearly-agreeing values of both the amplitudes and epochs for the several years show. The small shallow-water components, of which the amplitudes are A_3 and A_4, are also clearly brought out, though they are very small.

The K-tide is composed of a diurnal and of a semi-diurnal component, the former being the principal of all the diurnal components. The amplitude of this, A_1, is small, being only 4 inches.

The smallness of all these diurnals components, it is known, is a peculiarity of the Atlantic tides. The semi-diurnal component is the declinational component of the semi-diurnal tide, and the amplitude is only about 1.5 inches.

The L-tide and N-tide form a pair of components depending upon lunar parallax. As the epochs differ nearly 180°, these are somewhat opposite to each other in their effects at the time of perigee and apogee of the moon. The amplitude of the latter, it is seen, is greater than that of the mean solar tide. It is a peculiarity of our tides, especially along the New England coast, that the parallactic inequality in the lunar tide is larger and of more importance than the whole solar semi-diurnal tide.

The O-tide and P-tide are also diurnal components still smaller than the diurnal component of the K-tide. The effect of these diurnal components is to cause a difference in the heights of the forenoon and afternoon tides of the same day when the moon is not on or near the equator, and also an inequality in the intervals between high and low waters. The J-tide and Q-tide are also diurnal components, but the amplitudes of these tides at Sandy Hook are so small that they are of no practical importance, but the analysis shows that there are really such components.

The shallow-water components of these tides, the amplitudes of the principal of which are A_4 and A_6 of the M-tide and S-tide, and A_2 of the MS-tide and 2 SM-tide, are very small, the amplitudes of none of them amounting to 0.05 of a foot, and hence are of no importance for practical purposes.

The annual inequality, depending mostly upon meteorological causes, such as annual inequalities in the barometric pressure and the winds, and also in the ocean currents, is much smaller at Sandy Hook than it is along the New England coast, and the maximum, towards the last of July, is a little earlier.

The following are the amplitudes and epochs of all the components which it is necessary to use in the prediction of tides, including all the components of which the amplitudes, according to the preceding result, amount to one half tenth of a foot. These are given here, together with the designations of the components as engraved on the tide-machine, for the convenience of application in setting the machine.

Designation of component.	Amplitude, A.	Epoch, ϵ.
	Feet.	°
M_2	2.246	217.0
S_2	0.434	245.9
K_2	0.129	37.4
L_2	0.092	30.5
N_2	0.490	198.7
μ_2	0.069	227.0
ν_2	0.105	198
K_1	0.334	90.1
O_1	0.170	96.5
P_1	0.103	103.8
Annual inequality	0.068	208.

The suffixes 1 and 2 to the designating letters of the components denote diurnal and semi-diurnal components respectively.

The amplitudes and epochs of the components M_2, K_2, K_1, and O_1 are affected by the inclination of the lunar orbit to the ecliptic, and the values given here are the mean values, such as we would have if the moon moved in the ecliptic. Before these are used they must be reduced to the value for the given year, by a process just the reverse of that given in the Discussion of Tides in Penobscot Bay, §§ 25 and 26, by which they were reduced from the values obtained from the analysis of each year's observation to the mean values. Besides these reductions all the epochs must be reduced to the given year by subtracting the corresponding numbers found in Table II of the paper just referred to.

From the theoretical relations for the three principal components given in § 31 of that paper, we form in the same manner for the tides of Sandy Hook the following three relations for the diurnal components:

$$.334 - 0.66\ \delta\mu = (.5306 - 13.1\ \delta\mu)\ (1 + .230\ E)\ A_0$$
$$.170 = (.3813\ (1 - .2.30\ E)\ A_0$$
$$.103 = (.1730 - 13.6\ \delta\mu)\ (1 + .196\ E)\ A_0$$

The solution of these equations gives $\delta\mu = .00047$ and $E = .753$. The assumed mass of the moon being .0125, this correction makes it $.01297 = \frac{1}{77}$ nearly. Notwithstanding the smallness of the amplitudes of the components forming the first members of the equations above, these theoretical relations give a mass of the moon, so far as we know, not much in error. The mass of the moon obtained in the same manner from the tides of Penobscot Bay was $\frac{1}{83}$. The value of the constant E is here large and positive, while in Penobscot Bay it is $-.233$. This shows that the type of the diurnal tide at Sandy Hook is different from that of Penobscot Bay, an increase in the period of the component increasing the amplitude at the latter, but decreasing it at the former, station.

From the relations of the first two equations in § 32 of that paper we get for these tides, with the epochs of K_1 and O_1 in the preceding results

$$90.1 = L_0 + 13.18\ G$$
$$96.5 = L_0 - 13.18\ G$$

These give $G = -0.25$, which indicates that the maximum of the tide occurs one-fourth of a day before the maximum of the forces. This is an unusual result, but entirely in accordance with theory.

From the relations of § 33 of the paper referred to we get for these tides

$$.1931\ c = (.4852 - 36.2\ \delta\mu)\ (1 + .425\ E)$$
$$.0573\ c = (.1256 - 3.2\ \delta\mu)\ (1 + .460\ E)$$
$$.2218\ c = .1922\ (1 - 228\ E)$$

The solution of these equations gives $c = 1.1038$, $E = -1.167$, and $\delta\mu = .00106$. With this latter we get $\mu = .0125 + .00106 = .01356 = \frac{1}{74}$ for the moon's mass. The value of the constant c for Penobscot Bay, is 1.166. This constant being greater than unity indicates that the inequalities are smaller than the principal lunar component in proportion to the force, which is a result of friction diminishing large tides more in proportion than small ones.

The value of E is negative and very nearly the same as in Penobscot Bay. Upon the large negative value of this constant depends the peculiar type of the semi-diurnal tide all along our coast, in which the solar tide is very small, and the lunar parallactic inequalities very large. On this account the tides at Boston are 20 inches higher when the moon is in perigee than when it is in apogee, and there is about the same difference in Penobscot Bay. At Sandy Hook the difference in proportion to the whole range is about the same, but on account of the small range of the tides at the latter place, of course, the absolute difference is only about half as great.

From the relations of the first two equations of § 34 of the paper referred to above we get for the Sandy Hook station

$$217.0 = L_0$$
$$245.9 = L_0 + 24.4\ G$$

These give $G = 1.18$, which indicates that the maximum of the semi-diurnal tide occurs 1.2 days nearly after the maximum of the forces, or after the conjunction of the mean moon and sun in the case of the lunar and solar components.

APPENDIX No. 10.

DESCRIPTION OF A MAXIMA AND MINIMA TIDE-PREDICTING MACHINE.

By WILLIAM FERREL.

WASHINGTON, *November* 30, 1883.

SIR: I have the honor to submit the following report on the maxima and minima tide-predicting machine:

I have thought it best to go somewhat into detail in presenting the theory, construction, and method of operating it, so that those who shall have to use it hereafter may be able to understand not merely rules and directions, but also something of the mathematical theory upon which it is based. In a form suitable for determining the maxima and minima of the tides and their times of occurrence, the theory becomes much more complex than in the case in which the co-ordinates of height are required for given times. Still it will be seen from the following report with what great facility and rapidity the required results can be obtained from this complexity by means of the machine, the time required being little more than what is necessary for recording them.

The mathematical theory within itself, regarded merely as a tidal paper, will not be without interest and value, for the formulæ used in the machine are those best adapted to obtain the results accurately by computation. This, however, involves so great an amount of labor that it has been necessary heretofore to use more simple formulæ, requiring much less labor in computation, but which give often only very rough approximations to the true results. These can now be pretty accurately obtained with scarcely any labor.

I have the honor to be, very respectfully, yours,

WILLIAM FERREL.

J. E. HILGARD, Esq.,
Superintendent Coast and Geodetic Survey.

THE MAXIMA AND MINIMA TIDE-PREDICTING MACHINE.

INTRODUCTION.

1. The first machine for predicting tides was invented by Sir William Thomson about eight years ago. It was so constructed as to be run by clock-work and to give the tidal curve for a whole year or more on a long strip of paper wound on rollers. From this the height of the tide at any given time, or the times and heights of high and low waters only, may be read off. This machine, it seems, has never been used in the regular prediction of tides, and is said to be now on exhibition at the South Kensington Museum.

Subsequently Mr. E. Roberts, of the Nautical Almanac office, London, had another machine constructed upon nearly the same plan, but larger and with some improvements introduced. This machine has been successfully used for several years in predicting the tides of the principal commercial ports of India. A description of this machine was published in The Engineer of December 19, 1879.

The general principles and the plan upon which these machines have been constructed may be explained as follows:

The height of the tide, h, at any given time, t, is expressed by a series of harmonic terms of the following form:

$$(1) \qquad h = H_0 + A_1 \cos (i_1 t + c_1) + A_2 \cos (i_2 t + c_2) + \&c. = H_0 + \Sigma A_e \cos (i_e t + c_e)$$

in which

H_0 = the height of mean tide above an assumed plane,
A_e = the amplitude of any component of which the characteristic is e,
c_e = the value of the angle at any origin of t, as midnight, January 1,
i_e = the rate of change of the angle.

The number of components in the expression of h, if we include very small terms, is very great; but the number of those which are of any practical importance is generally only about fifteen or twenty, often less. The values of i_e are obtained from astronomical developments, and they depend upon the known periods and other elements of the lunar and terrestrial orbits and the period of the earth's rotation on its axis. The values of A_e and c_e have to be obtained for each tide station from an analysis of the hourly values of h, for a year or more, obtained directly from observation, or from the curves of a self-registering tide-gauge. The method of doing this has been given in detail in Appendix No. 11, Report of Coast and Geodetic Survey for 1878.

With the values of these constants for any given station, and the known values of i_e, the values of h at any given time t, can be computed from the preceding expression. The amount of labor, however, involved in such a computation for fifteen or twenty components it is readily seen is very great.

The times and heights of the maxima and minima of h cannot be directly computed, since the time or value of t in the expression of h for high or low water is not known, but is one of the things required. To obtain this, therefore, it is necessary to compute several hourly co-ordinates near this time, which is always approximately known, and then from these the maxima or minima and the time of its taking place can be obtained by well-known methods.

2. By the machines of Sir William Thomson and Mr. Roberts the function h is represented graphically by means of the tide curve, in which the co-ordinates are the times t and the heights h. The summation of the effects of the several components upon the value of h at any time is accomplished in the following manner: Let a fine chain or very flexible wire be fastened at one end as at a, Fig. 1, Plate I, and pass over the pulleys 1, 2, 3, 4, &c. If these pulleys are attached to cranks and axles, as represented on Plate II, and these axles are made to turn by means of machinery in periods which have the same relations to one another as the periods in the components of h in the preceding expression, and the centers of the pulleys are thrown out on the cranks at distances from the center which have the same relations to one another as the amplitudes A_e of the several components, and the initial angles, or directions of the cranks from the centers, correspond with the angles c_e at the epoch or time of $t = o$, then, if the machinery is kept in motion, the other end of the chain, at b, describes upon paper wound off on cylinders, kept turning also in connection with the rest of the machinery, a curve b, c, d, e, f, &c., which represents the tide curve. From this curve the heights of high and low waters, f, e, d, &c., above any assumed plane, which is usually that of mean low water, as represented by gh in Fig. 1, can be measured, and the approximate times of high and low waters can be estimated by the abscissas on the line gh, which are in proportion to the time.

If only one of the pulleys were thrown out from the center, say that of the mean lunar semi-diurnal component, which is generally much larger than any of the others, we should then have a regular curve b, c', d', &c., following the law of cosines, and the heights of all high and all low waters would be the same and their times would be at regular intervals of 12 lunar hours. The effect of all the other comparatively small components is to distort the regularity of the curve, causing the heights of both high and low waters to differ at different times and the high and low waters to occur at irregular intervals.

If there are one or more diurnal components superimposed upon the semi-diurnal, the effect is to cause considerable differences between the two high or the two low waters of the same day, and also to cause great irregularities in the intervals of high and low waters of the same day, as represented by the curve *f*, *e*, *d*, *c*, &c., in Fig. 1.

The distances between each of the cranks and pulleys from the points of suspension as of (1) from (*a*) and (2), or (2) from (1) and (3), Fig. 1, must be so great in comparison with the distances to which the pulleys are thrown out from the center that the deviation from parallelism of the strands of chain or wire between the pulleys will not affect sensibly the measured distances. The pulley, therefore, belonging to the mean lunar semi-diurnal component, say pulley (1) in Fig. 1, should be at a considerable distance from the points of suspension, (*a*) and (2). Of course the arrangement of the pulleys and distances apart may be varied in an infinite number of ways to suit best the space to be occupied by them, and the effect and the principles involved will remain the same.

In Mr. Roberts' machine the pulleys are not swung around on cranks, but are made to oscillate vertically by means of pins which are thrown out on the cranks to their proper distances, and which work in grooves of horizontal beams to which the pulleys are attached. Of course, with this arrangement, the strands are always parallel, and distance from the points of suspension need not come into consideration.

In Sir William Thomson's machine only ten of the larger components are taken into account These, however, are all that are of much practical importance generally, especially if the range of the tides is not very great. In Mr. Roberts' machine twenty components are provided for, but the amplitudes of some of these are so small, even in tides of large range, that they are of little importance taken separately, but still the resultant of all these, together with all the numerous components which are necessarily neglected, may be considerable.

3. The plan of the maxima and minima tide-predicting machine is very different from that of the machines just referred to, though comprising some of their features. The clock-work and the graphic representation of the tide on paper are dispensed with. The machinery is run by the left hand, by means of a crank at the side of the machine, and the heights of high and low waters and the times of their occurrence are read from the face of the instrument, as they are reached in turning, and recorded by the right hand in blanks ready for the printer. It does not give the intervening heights of the tide, at least directly from the face, and it is therefore called the maxima and minima predicting machine.

The theory and plan of this machine were first submitted to the Superintendent of the United States Coast and Geodetic Survey in the spring of 1880. It received a favorable consideration, and the construction of a machine upon the plan submitted was at once decided upon. A paper was also read in the following August before the American Association for the Advancement of Science in session at Boston, Mass., in which the theory and plan were briefly explained.

There were various delays in engaging a mechanist and in making all the preliminary arrangements for the construction of the machine. It was finally undertaken by Fauth & Co. of this city, under the supervision of Mr. G. N. Saegmuller, of the Coast and Geodetic Survey. The work, however, was not commenced until late in the summer of 1881, and it was not completed until the fall of the next year.

MATHEMATICAL THEORY OF THE TIDE-PREDICTING MACHINE.

4. By a transformation of the last term of the second member of (1), given in the introduction, we have

$$(2)\quad h = H_0 + \Sigma\ A_e \cos\left\{ (i_1\, t + c_1) + \Big((i_e - i_1)\ t + c_e - c_1 \Big) \right\}$$

$$= H_0 + \cos(i_1\, t + e_1)\, \Sigma\, A_e \cos\Big((i_e - i_1)\, t + c_e - c_1 \Big) - \sin\,(i_1\, t + c_1)\, \Sigma\, A_e \sin\Big((i_e - i_1)\, t + c_e - c_1 \Big)$$

$$= H_0 + \cos\,(i_1\, t + c_1)\ M - \sin\,(i_1\, t + c_1)\ N$$

in which

$$(3)\qquad \begin{cases} M=A_1+\Sigma\ A_e \cos(u_e\ t+C_e) \\ N=0+\Sigma\ A_e \sin(u_e\ t+C_e) \\ u_e=i_e-i_1 \\ C_e=c_e-c_1 \end{cases}$$

In these expressions A_1, i_1 and c_1 are supposed to belong to the mean semi-diurnal lunar component, which is, in general, the principal component in (1), and only the other, generally smaller, components are comprised under the sign Σ in the expressions of M and N.

By a still further transformation of the last form of the preceding expressions of h, we get

$$(4)\qquad h=H_0+R\cos(i_1\ t+c_1+\beta)$$

in which

$$(5)\qquad R=\sqrt{M^2+N^2} \qquad\qquad \tan\beta=\frac{N}{M}$$

If in the preceding expressions we knew the value of t for the times of high and low waters, we could, with the known values of i_e, and the values of A_e and c_e obtained for each station from observation, compute the values of h at these times. The next step, therefore, is to determine the times of the maxima and minima of h.

From the second form of the preceding expression of h, we get

$$-\frac{dh}{i_1\,dt}=\sin\ (i_1\ t+c_1)\ \Sigma\frac{i_e}{i_1}A_e\cos\Big((i_e-i_1)t+c_e-c_1\Big)+\cos\ (i_1\ t+c_1)\ \Sigma\ \frac{i_e}{i_1}\ A_e\sin\Big((i_e-i_1)\ t+c_e-c_1\Big)$$

$$=\sin\ (i_1\ t+c_1)\ M'+\cos\ (i_1\ t+c_1)\ N'$$

in which

$$(6)\qquad \begin{cases} M'=A_1+\Sigma\ \frac{i_e}{i_1}A_e\ \cos\ (u_e\ t+C_e) \\ N'=0+\Sigma\ \frac{i_e}{i_1}\ A_e \sin\ (u_e\ t+C_e) \end{cases}$$

At the times of maxima and minima the first member of the preceding equation vanishes, and it can then be expressed in the following form:

$$(7)\qquad 0=R'\sin\ (i_1\ \tau+c_1+\beta')$$

in which

$$(8)\qquad \begin{cases} R'=\sqrt{M'^2+N'^2} \\ \tan\beta'=\frac{N'}{M'} \end{cases}$$

and in which τ is the value of t at the times of maxima or minima.

Equation (7) is satisfied with

$$i_1\ \tau+c_1+\beta'=n\pi$$

n being o or any integral number, and consequently we have

$$(9)\qquad i_1\ \tau=n\pi-(c_1+\beta')$$

With this expression of $i_1\ \tau$, which is the value $i_1\ t$ at high or low waters, we get from (4), putting H for the value of h at those times,

$$(10)\qquad H=H_0\pm R\cos(\beta-\beta')$$

in which the positive sign belongs to high waters and the negative to low waters, and in which the multiples of $n\ \pi$ are neglected since they do not affect the cosine, except to make each alternate one negative, as indicated by the double sign $\pm$.

With the values of R and β obtained from (3) and (5) and that of β' from (6) and (8_2), both with $t=\tau$, (10) would give the value of H; but τ, which is needed at the very outset in the computation, is not known, but is one of the things required, and can only be obtained from (6), (8_2), and (9) by a series of approximations; and although a second, or at most a third

approximation is generally sufficient, yet as the expressions of (6) usually comprise fifteen or twenty terms, the amount of computation for each of the four diurnal values of τ is very great.

5. The value of $(\beta-\beta')$ is generally so small, especially in the Atlantic tides, that its cosine can be put equal to unity, and then (10) becomes

$$H = H_0 \pm R. \tag{11}$$

It is seen from (3) and (6) that the amplitudes of the components in the expressions differ by the factor $i_e : i_1$. This for all the semi-diurnal components differs little from unity, but for the diurnal components in which i_e is only about one-half of i_1, this factor differs but little from one-half of unity. Hence the differences between M and N in (3) and those of M′ and N′ in (6), and consequently the difference between β and β', depends almost entirely on the diurnal components, for the quarter-diurnal and other components of short period, in which the factor $i_e : i_1$ is greater than unity, are generally very small. In the Atlantic tides, therefore, in which the diurnal components are very small, the angle $(\beta-\beta')$ is likewise small.

In the Gulf of Mexico, however, and on the Pacific coast of North America, where the diurnal components are very large in comparison with the semi-diurnal, the value of $(\beta-\beta')$ may be very large, even approximating to 180°. When it is greater than 90° the last term of (10) changes sign, and one high water is below mean level, or one low water above it.

6. In (10) the values of R, β and β' to be used are those corresponding to $t=\tau$ in (6) and (8), τ being the time of high or low water. But it is seen by comparing (10) and (11) that this value of R in the latter is too great to give the true high or low water, and that it requires to be multiplied into $\cos(\beta-\beta')$. It becomes important, therefore, to determine at what time R has a value so as to make (11) strictly correct, so as to dispense with the factor $\cos(\beta-\beta')$ in (10).

Putting R_τ for the value of R at the time $t=\tau$, we must, for this purpose, have

$$R_\tau - \delta R = R_\tau \cos(\beta-\beta') = R_\tau - \tfrac{1}{2} R_\tau \sin^2(\beta-\beta') + \tfrac{1}{8} R_\tau \sin^4(\beta-\beta_1) - \text{etc.}$$

or, neglecting small terms in the development, we have

$$\delta R = \tfrac{1}{2} R_\tau \sin^2(\beta-\beta') \tag{12}$$

From (3) and (5) we get by differentiation at time τ

$$d R = -\Sigma A_e \sin(u_e \tau + C_e)\, u_e\, dt \tag{13}$$

From this we get

$$\delta R = -\Sigma A_e \sin(u_e \tau + C_e)\, u_e (\tau'-\tau) \tag{14}$$

in which τ' is the value of t which satisfies (12), or which makes $R^{\tau'} = R_\tau \cos(\beta-\beta')$. In this expression $u_e(\tau'-\tau)$ must not be so large that $\cos u_e(\tau'-\tau)$ cannot be taken equal unity, or sin $u_e(\tau'-\tau)$ cannot be regraded as equal to the arc.

From (4) we get at the time τ, since then $dh=0$,

$$0 = d R \cos(i_1 \tau + c_1 + \beta) + R_\tau i_1 \sin(i_1 \tau + c_1 + \beta)\, dt$$

or putting for i_1, τ its value in (9), neglecting the multiple $n\pi$, since it does not effect sines or cosines if we consider either high or low waters separately, we get by putting $\cos(\beta-\beta')=1$, and $\sin(\beta-\beta')=(\beta-\beta')$

$$d R = - R_\tau i_1 (\beta-\beta')\, dt$$

From this and (13) we get

$$\Sigma A_e \sin(u_e \tau + C_e)\, u_e = R_\tau i_1 (\beta-\beta')$$

From this, (14) and (12), we get

$$(i_1 \tau' - \tau) = -\tfrac{1}{2}(\beta-\beta')$$

Putting τ'' for the value of t when in (4) $(i_1 t + c_1 + \beta) = 0$.

(15) $$i_1 \tau'' = n\pi - (c_1 + \beta)$$

From this and (9) we get

$$\beta - \beta' = i_1 (\tau'' - \tau)$$

With this value the preceding equation gives

(16) $$\tau' = \tau + \tfrac{1}{2}(\tau'' - \tau) = \tfrac{1}{2}(\tau + \tau'')$$

Hence (11) becomes strictly correct if we use the value of R belonging to the time $t = \tau'$, and hence we have

(17) $$H = H_0 + R\,\tau'$$

in which τ' is determined by (16). This time is at equal intervals from τ and τ''. It must be remembered, however, that this cannot be used, except approximately, if $\beta - \beta' = i_1 (\tau'' - \tau')$ is so large that unity cannot be used for its cosine and the arc for its sine.

7. From what precedes it is necessary to compute the times of high and low waters τ from (8) and (9), which implies the computation of M' and N' in (6), which, as has been stated, requires a second or third approximation, since the value of t to be used in (6) is that of τ, which is the quantity sought. With this value, however, when obtained, and the value of β' already obtained, (3), (5) and (10) give directly the value of H, the height of high or low water.

For a very numerous class of tides, however, embracing nearly all those of our Atlantic coast, in which, on account of the smallness of the diurnal components, the values of M and N, (3) and those of M' and N' (6), and consequently the values of R and β and those of R' and β', differ but little in the two sets of formulæ, we can, at a very small sacrifice of accuracy, so small as to be of no importance, adopt compromise formulæ which will answer for both, and from which both the times and heights of high and low waters may be computed.

If for the values of M and N, or for those of M' and N' we put $M'' + \delta M''$ and $N'' + \delta N''$, $\delta M''$ and $\delta N''$ being small corrections of M'' and N'' to get the true values, and if we also put $\delta R''$ and $\delta\beta''$ for the corresponding corrections of R'' and β'' the new values of R and β, we get from the development of the expression (5) or (8), neglecting quantities of the third and lower orders,

(18) $$\begin{cases} \delta R'' = \dfrac{M''\,\delta M'' + N''\,\delta N''}{R''} \\ \delta\beta'' = \dfrac{M''\,\delta N'' - N''\,\delta M''}{R''^2} \end{cases}$$

Since in the class of tides referred to, the value of N'' is much smaller than that of M'', on account of the constant A, (3) and (6), which is the amplitude of the mean lunar component, and comes in the expression of the latter and not that of N, it is seen from (17) that $\delta R''$ depends mostly on $\delta M''$, an error in M'', while that of $\delta\beta''$, and consequently of the times, depends mostly upon the error of N'', that is, upon $\delta N''$.

If we therefore put

(19) $$\begin{cases} M'' = M = \Sigma\, A_e \cos (u_e t + C_e) \\ N'' = \tfrac{1}{2}(N + N') = \Sigma\, \dfrac{i_1 + i_e}{2\, i_1} A_e \sin (u_e t + C_e) \end{cases}$$

and use these values instead of M and N in (3) or of M' and N' in (6), we shall have in the case of high waters computed by (3)

(20) $$\delta M'' = 0 \qquad \delta N'' = \tfrac{1}{2}(N - N')$$

With the values of (18) and (19) we get from (18), in this case,

(21) $$\begin{cases} \delta R'' = \dfrac{\tfrac{1}{2} N'' (N - N')}{R''} \\ \delta\beta'' = \dfrac{\tfrac{1}{2} M'' (N - N')}{R''^2} \end{cases}$$

In the case of β' in (6) the error of M$''$, or δ M$''$, would be (M − M$'$), and the value of $\delta\ \beta''$ in this case would be more accurately given by (18_2), using this value, than by (21_2), but since, as has been explained, a small error in M$'$ has a very little effect upon the value of β', in the class of tides here considered, (20_2) can be used in this case also without much error.

From (3_2) and (6_2) we get

$$N - N' = - \Sigma A_e \frac{e}{i_1} \sin (u_e t + C_e) \tag{22}$$

Since the values of i_e are very nearly the same for all the semi-diurnal components, and consequently differ but little from i_1 (3_3), this makes the terms in (21) depending upon the semi-diurnal components very nearly vanish, and since the values of i_e for the diurnal components are very nearly equal to $\frac{1}{2}\ i_1$, the value of the factor $u_e : i_1$ is very nearly $\frac{1}{2}$. The value of (N − N$'$) therefore depends almost entirely upon the diurnal components, and hence when the amplitudes A_e of these are small (N − N$'$) must be small, and, consequently, the corrections or errors given by (21) are small.

8. From (3) and (8) we get approximately, for the kind of tides here considered,

$$\beta - \beta' = \frac{N - N'}{R} \tag{23}$$

Hence by (21) the value of ($\beta - \beta^1$) depends almost entirely upon the diurnal components, and is small where these are small, and sensibly vanishes when they vanish.

With the values of M, N, and M$'$, N$'$, and by means of these the values of M$''$, N$''$, and δ M$''$ and δ N$''$, (5) gives with M$''$ and N$''$ instead of M and N, the value of R$''$, and then (21) gives the amount of error in the heights and times pertaining to the compromise formulæ.

The amplitude of the maximum lunar diurnal tide at Boston Harbor is 0.58 feet. This occurs when the maxima of the two lunar components coincide about the time of greatest declination. Hence by (22) we shall have, so far as these two components are concerned, N − N$'$ = ± 0.29 feet at the maximum. The mean maximum value of N is 1.0 feet nearly, and R$''$ = 5 feet approximately. With these data (20) gives δ R$''$, equal about one-third of an inch for the error in the heights, and $\delta\ \beta''$ = 0.03 in arc in terms of the radius corresponding to 1°.7 in arc, or about 3.5 minutes in time for the error in the times of high or low water. The effect of the solar diurnal tide in summer and winter would be about one-third of this, which would sometimes combine with the lunar diurnal components and increase the effect a little, but at other times counteract and diminish it. The preceding may be regarded as the mean of the maximum errors of the compromise formulæ for all the large-range tides along the New England coast.

At New York Harbor the value of R$''$ is about 2.23 feet, and the mean maximum value, as at Boston about $\frac{1}{5}$ R$''$. The amplitude of the mean maximum of the diurnal tide here is 0.43 feet, and hence N − N$'$ = ± 0.21 feet. With these values (20) gives δ R$''$ = 0.26 inch, and $\delta\ \beta$ = .048 in arc, corresponding to about 5 minutes in time for the mean maximum of the errors of the compromise formulæ, the former for those of the heights and the latter for the times of high and low-waters in New York Harbor.

In the same manner the formulæ can be tested for each tide station. It is probable that the error for none of the stations of the Atlantic coast would amount to as much as a half inch in the heights, but in the short range flat tides the times might be in error ten minutes or more. This latter, however, is an error more in appearance than in reality, for the heights for ten minutes before or after high or low waters, do not change one-tenth of an inch, even with an amplitude of tide as great as in New York Harbor.

If in (19) we put N$''$ = N$'$ instead of $\frac{1}{2}$ (N + N$'$), it will give the times accurately, with a very small increase of the error in the heights, which would still be too small to be of any consequence in most, if not all, of our Atlantic tides. Or the value of N$''$ can be so taken as to throw a little of the error in the times, but less than that given by (19).

In the short range semi-diurnal tides of the Gulf of Mexico and the Pacific coast, with diurnal tides which have comparatively a very large range, the compromise values of (19) cannot be used, but in such tides the values of the times must be obtained from (8) and (9), and then with these

the heights obtained from (3), (5), and (10). With the values, however, of τ and τ'' from (9) and (15), we get that of τ' from (16), which in (3) and (5), gives $R\tau'$, with which (17) gives H, thus dispensing with the factor $\cos(\beta-\beta')$ in (10). This, however, in computation would involve a vast amount of labor for so small a matter, but in the mechanical solution of the problem it will be seen that it can be done in an instant of time.

It rarely happens that (17) cannot be used with sufficient accuracy, but sometimes the value of $(\beta-\beta')$ becomes such that unity cannot be used instead of its cosine or the arc instead of its sine, and then (17) is not strictly correct, since these restrictions of the value of $(\beta-\beta')$ were introduced in obtaining that expression of H. In such cases (10) must be used, but they only occur when R or $R\tau$ are very small, and the height of high or low water is very nearly that of mean level, and the value of $\beta-\beta'$) and the times of high or low waters are somewhat uncertain on account of the tide wave being very flat. But the whole value of $R\cos(\beta-\beta')$ in (10) is then very small.

9. So far we have gone upon the hypothesis that the amplitude of the resultant of two or more tide components, superimposed upon one another, is equal to the sum of the amplitudes of the several components. This, however, is never strictly the case, and the amplitude of the resultant is often considerably less than this sum. This is due to the fact that friction is not proportioned to the velocity, but to a power of the velocity somewhere between the first and second powers. The effect of this is to diminish large tides more in proportion than the smaller ones, and consequently to cause the amplitude of the large tides to be smaller, and of the small tides to be larger, than they would be if the effect of friction were proportional to the amplitude and velocities.

In the variations of amplitude of the resultant of one principal component and a number of smaller ones, the preceding effect of friction is the same as if the amplitude of each of the smaller components was diminished by a certain amount when superimposed upon the larger and principal component, so as to have the phases coincide. But when the phases differ 90°, the amplitude of the resultant is very nearly that of the principal component, and we then simply have the average effect of friction, and the effect of the smaller component in changing the times of the maxima and minima is that of the component with undiminished amplitude. Hence, this effect of friction does not affect the times of high and low waters of the resultant tide, but simply causes a little flattening where one or more of the smaller components are superimposed upon the principal component.

In the tides of Boston Harbor, from an analysis and discussion of nineteen years of observations, it was found that this effect of friction on high and low waters was that which would be caused by a diminution of the amplitudes of the smaller components when superimposed upon the principal one, in the ratio of 1 to .634. In New York Harbor, from the same number of observations, this ratio was found to be as 1 to .75, or a diminution of one-fourth. At Brest, however, the effect was found to be very small. Of course, it depends very much upon depth of water and other local circumstances.

In the form of the tidal expression in (4) the preceding effect of friction is taken into account pretty nearly, especially where N is small, by decreasing the amplitudes A_{e} in the expression of M in (3), where the ratio of reduction is known from a discussion of observations. It is seen from (5) that the amplitude R of the resultant tide, when N is small, as it generally is in our Atlantic tides, depends mostly upon M. Where the exact ratio of reduction is not known it is best to diminish these amplitudes a little, for a better agreement of computation with observation is generally obtained when this is done.

It should be remarked here that the amplitudes A_{e} of the smaller components, comprising all except the mean lunar and principal one, as obtained by the harmonic analysis of hourly co-ordinates, are diminished by one-half the maximum effect, which occurs when their phases coincide with that of the principal component, since these amplitudes are obtained from measurements for all the different relations between the phases. The amplitudes, therefore, which are to be used in (3) should be a little less than those in the expression of M, but as much greater in that of N. From an actual comparison of computation with observations of the heights and times of high and low waters at Boston Harbor, it has been found that the expressions of (10) and (9) will not give both accurately unless the values of A_{e} in the expression of M in (3) are one-third less than the values which have to be used in the expression of N, to give the times correctly.

MECHANICAL SOLUTION OF THE PROBLEM.

10. In order to obtain the times τ of high or low waters from (9) it is necessary first to determine the angle β'. This is given by the geometrical construction of a right-angled triangle $c\,m'\,n'$, Fig. 2, Plate I, in which $c\,m' = M'$ and $m'\,n' = N'$ in (6), as is seen from the expressions of (8). By comparing the expressions of M′ and N′ in (6) with that of h in (1) it is seen that they are similar except that the expression of N′ has sines instead of cosines and has no constant term corresponding to that of H_0 in (1) or that of A_1 in the expression of M′ in (6). The value of M′, therefore, at any time t may be obtained mechanically by the same method as that by which h in (1) is obtained, as explained in the introduction. Since the number of variable terms and the periods in the expression of N′ are the same as those in the expression of M′, its value can be obtained mechanically in the same way by having a chain passing over pulleys on cranks at the other end of the same axles, and placing these cranks at right angles to the former, so as to give the function represented by sines instead of that of cosines.

In Fig. 2, Plate I, let $c\,m' = M'$ be the co-ordinate given at any time by the part of the machine adapted to cosines, just as h is given by Mr. Roberts' machine, the part co being the amplitude A_1 of the mean lunar and principal semi-diurnal component, and om' the resultant of all the other terms in the expression of M′, comprising all the other, generally much smaller, components. Also let $m'\,n' = N'$ be the other co-ordinate at any given time, t, given by the part of the machine adapted to the sines. In order to obtain mechanically the value of the angle $\beta' = m'c\,n'$, it is necessary to have an arrangement by which the values of M′ and N′ are not only represented by linear measures, but also that these measures be given on lines at right angles, as on lines in the directions of $c\,m'$ and $m'n'$. The point n' then determines the direction of the line $c\,n'$, and the angle $m'\,c\,n' = \beta'$, which can be measured on the circle $f\,d\,e\,a$, counting from the point f. In order to this, instead of a pen or pencil, as at b, Fig. 1, oscillating vertically above the line of mean level, we must have a horizontal bar with a slit in it oscillating vertically above and below the point o, by means of a sliding frame, as represented in Fig. 3, Plate I, this frame being controlled by the chain from the cranks adapted to the cosines and connected with the frame at the point e. The mere weight of the frame gives the chain sufficient tension. The space $c\,m'$ represents the value of M′ at any time and is one of the co-ordinates which determines the point n'. If now we have another bar with a slit in it placed vertically and oscillating horizontally about the central line $c\,m'$ by means of a sliding frame, as represented, with the chain passing over the pulleys on the cranks adapted to the sines and attached to the frame at b, the distance $m'\,n'$ will be the measure of the other co-ordinate N′, and the intersection of the two slits determines the position of the point n' and of the line $c\,n'$. The frame moving horizontally must have a chain attached to it on the other side, which passes over some fixed pulley and has a weight suspended which gives it sufficient tension. Since the expression of N′ has no constant term the point n' will fall equally on different sides of the central line $c\,m'$, and consequently the value of β' may be either positive or negative.

If, while the machinery is in motion giving at different times different positions of the line $c\,n'$ and values of the angle β', there is an index $c\,e$, Fig. 2, made to turn around the center c in each lunar half day, the motions of the axles and cranks being arranged in accordance with this measure of time, the angle described by the index $c\,e$ in the time t will be $i_1\,t$, and the degrees as measured on the circle $f\,d\,ea$, counting from f, will be $i_1\,t+c_1$, if the index is set at the time $t=o$, as 0^h of January 1, so as to make the angle $f\,dbe=c_1$, the phase of the mean lunar semi-diurnal component in (1). When ce coincides with cf we have $i_1\,t+c_1=n\,\pi$, or $i_1\,t=n\,\pi-c_1$, the value of n being o, or any integral number equal to twice the number of lunar half days which have elapsed since the epoch. The values of t given by this equation for any integral value of n, are the times of the high waters of the mean lunar semi-diurnal tide, and they must necessarily occur at regular equal intervals of time.

But the times τ of high or low waters are determined by the condition of (9), and hence they occur at the times when ce is in conjunction with ca or with ca produced back to b, since in the former case the condition of (9) is satisfied for even values of n, and in the latter for the odd values, corresponding to the low waters. Hence the times of high or low waters are determined mechanically by simply watching the conjunctions of the lunar index ce with ca, or with ca pro-

duced back, and noting the times. Hence we see with what great facility and little labor these times can be determined mechanically, whereas by computation, we have seen, the amount of labor is immense, involving the computation of M′ and N′ from (6) for fifteen or twenty terms for assumed values of t in several approximations. We have a case similar to this, though comparatively very simple, in the determination of the time when the hour and minute hand of a clock come together. A novice in analysis might be puzzled to determine it analytically, but to do it mechanically all he has to do is to turn the minute hand until it comes in conjunction with the hour hand, and then read off the time from the dial. With the same facility are the times of high and low water determined by the method explained above.

The principle involved in the determination of τ, both by computation and mechanically, is the same. In the computation we proceed with a series of assumptions and verifications until an assumption of t is made which satisfies (9) with sufficient accuracy. So each part of the motion of the machine is an assumption which has to be verified, but as the machine makes all the computations simultaneously with the assumptions, all we have to do is to continue the motion until the verification takes place, which is when ce comes in conjunction with ca, or ca produced back, for then, as we have seen, the condition of (9) is satisfied.

It should be observed here that for the conditions of (9) to be satisfied when the conjunctions take place, it is necessary, since β' in (9) has the negative sign, that the positive values of N′ should be to the left in Fig. 2, in the direction of m' n'.

Since the index ce performs a revolution each lunar half day, any arrangement for reading off the time from the circle $f\ d\ e\ a$ would necessarily have to give lunar time. In order to have the solar time, therefore, it is necessary to have a second index, cd, called the solar index, the motion of which has such a relation to that of ce as to reduce the lunar to solar time. When the lunar index occupies such a position as to make the angle $fdbe=c_1$, as at the time of the epoch, or $t=o$, then cd should coincide with cf and denote 0^h of solar time. As ce moves around toward ca or ca produced back, cd moves a little faster and points out the time elapsed in solar time, and when ce comes in conjunction with ca or ca produced back, it indicates the time of high or low water in solar time.

11. Having the time τ, (10) gives the value of H, and this requires the solution mechanically of the expressions of M and N in (3) and of the right-angled triangle by (5), which is done in precisely the same manner as in the case of M′ and N′ in (6) and of the right-angled triangle in (8). In the former case we needed β', one of the angles of the triangle, but in this case we need the hypothenuse R. This value is needed at the times $t=\tau$, and hence its value must be read off at the times τ, and multiplied into cos $(\beta-\beta')$, if this varies sensibly from unity.

By comparing the expressions of M and N in this case with those of M′ and N′ it is seen that the only change to be made is to throw the pulleys out on the cranks in accordance with the amplitudes A_e instead of $A_e\,\frac{i_e}{i_1}$, and this, unless great accuracy is required, needs a change only in the amplitudes of the diurnal components, since for the others the factor $i_e : i_1$ differs but little from unity. In this case, instead of the co-ordinates M′ and N′, represented in Fig. 2 by cm' and m' n', we have M and N represented by cm and mn, differing but little from the others unless the diurnal components are large.

The angle β is determined mechanically by observing the value of the angle $m\ c\ n$, Fig. 2, at the time of conjunction of the index ce with $c\ a'$, just as β' is, by observing the value of the angle $m'\ c\ n'$ at the time of conjunction with ca. When $(\beta-\beta')$ does not exceed 30°, or the times of the two conjunctions differ more than about one hour of time, which they rarely do, formula (17) can be used, which requires that the value of R be observed at the time τ' given by (16). The time τ having been observed and recorded in determining the times of high and low waters with the first setting of the machine, after the small change has been made in the setting for getting the heights, the value of τ'' is the time of conjunction of ce with ca', and then at half the interval of time from τ'' to τ is the time of reading the value of R. This, by (17), applied to H_0 gives H, the height of high or low water sought. For convenience there must be an arrangement by which the distance R is measured on some scale together with the constant H_0, so that the value of H can be read directly from the scale by means of an index.

Where (19) is used, as it may in most of our Atlantic tides, the machine is set at the start for both the times and heights of high and low waters, and both are read at the time of conjunction of the index *ce* with a line, indicated by the machine, which falls intermediate at equal intervals from *ca* and *ca'*. This time, therefore, corresponds with the time given by (16), which is the time of reading the value of R, where (17) is used.

CONSTRUCTION OF THE MACHINE.

12. In the construction of the machine are embraced nineteen of the largest tide-components and all which are of any practical importance. The designations of these components and the hourly rates of change of the angles, denoted by i_e in the preceding formulæ, and also the values of u_e, are given in the following table:

TABLE I.

Designation.	e	i_e	$i_e - i_1 = u_e$	$\frac{i_e}{i_1}$	$\frac{u_e}{i_1}$	Error in a year.
						°
M_2	1	28.984104	0.000000	1.000	0.000000	....
S_2	2	30.000000	+ 1.015896	1.035	+ 0.0350501 = [illegible] + .0000021	−0.52
K_2	3	39.082138	+ 1.098034	1.037	+ 0.0378840 = [illegible] + .0000015	−0.36
L_2	4	29.528478	+ 0.544374	1.018	+ 0.0187818 = [illegible] − .0000013	+0.33
N_2	5	28.439730	− 0.544374	0.980	The same as L_2 but negative	+0.33
λ_2	6	29.455626	+ 0.471522	1.016	+ 0.0162683 = [illegible] + .0000016	−0.40
ν_2	7	28.512582	− 0.471522	0.983	The same as λ_2 but negative	−0.40
μ_2	8	27.768208	− 1.015896	0.957	The same as S_2 but negative	−0.52
T_2	9	29.958932	+ 0.974828	1.033	+0.0336332 = [illegible] + .0000019	−0.49
U_2	10	27.341696	− 1.642408	0.943	− 0.0566658 = − [illegible] − .0000009	+0.22
K_1	11	15.041069	−13.943035	0.519	− 0.481058 = − [illegible] + .000002 ...	−0.5
O_1	12	13.943036	−15.041068	0.481	− 0.518942 = − [illegible] − .000005	−1.2
P_1	13	14.958932	−14.025172	0.516	− 0.483892 = − [illegible] + .000004	−1.0
Q_1	14	13.398661	−15.585443	0.462	− 0.537724 = − [illegible] − .000002 ...	+0.5
Q'_1	15	14.496694	−14.487441	0.500	−0.499680 = − [illegible] − .000001	+0.2
*$(MS)_4$	16	58.984104	+30.000000	2.034	+ 1.035050 = [illegible] − .000005	+1.2
*M_4	17	57.968208	+28.984104	2.000	+ 1.000000	....
*M_6	18	86.952312	+57.968208	3.000	+ 2.000000	....
S'	19	0.985648	....	....	....	....

* Shallow-water components.

These components are mostly the same as those given in Schedule I of the Discussion of Tides in Penobscot Bay, Appendix No. 11, of the Report of the Coast and Geodetic Survey for 1878. A few of the very small components given there are omitted, and two others, considered of more importance, and designated by u_2 and $2'_1$ have been added. The former is one of a pair of smalli components depending upon the lunar declination and perigee which, on account of the small value of i_e, gives a sensible tide along our Atlantic coast, although the coefficient of the corresponding term in the development of the tidal forces is small and would not give a sensible tide with an ordinary value of i_e. The other, Q'_1, depends upon the solar ellipticity of orbit, and has a value of i very nearly $\frac{1}{2}$ i_2, and it is found, in the analysis of tide observations, to give often a very sensible component. The component designated by S' is an annual inequality in the heights of the tides arising from an annual inequality of mean level, due almost entirely to meteorological causes, and is generally found to have an amplitude of two or three inches. The value of i_e given in the table for this component is the diurnal rate of change of angle.

Besides the components in the preceding table, the four components in the schedule referred to above, designated by M'_1 and M'_3 in the semi-diurnal components, in which the values of i_e are almost the same as those of M_2 and K_2 in the preceding table, and the two diurnal components designated by M'_3 and M'_6, of which the values of i_e are very nearly the same as those of K_1 and O_1 above, are combined with the components in the preceding table which have nearly the same values of i_e and consequently nearly the same period. These components with periods differing very little from

others arise from the slow motion of the moon's node. To take them into the account with the others it is only necessary to change the amplitudes and epochs a little for the several years of the nodal period, for which tables will be given. There are, therefore, these four other components also taken into account, but not by means of separate axles and cranks.

The suffixes 1, 2, 3, &c., to the letters of designation of the several tide components in the preceding table indicate, respectively, diurnal, semi-diurnal, &c., components.

13. In any machine for the solution of equation (1), the periods of revolution have to be diurnal, semi-diurnal, &c., the hourly rates of change of the angles being i_e given in the preceding table. But it is seen from (3) and (6) that the hourly rates of change of the angles are u_e, which by the preceding table are comparatively very small for the semi-diurnal components, so that instead of semi-diurnal periods we have only monthly and half monthly periods. The mechanical solution of the equation, therefore, as transformed in (4) requires comparatively very slow motions of the machinery for the semi-diurnal components. For the diurnal components, however, we still have the diurnal priods. It is also seen from (3) and (6) that for the mean lunar and principal semi-diurnal component we have simply the constant A_1, needing no axle and cranks, so that these are required for the components only which are generally very small in comparison, and which can be regarded simply asperturbations of this principal component.

14. In the construction of the part of the machine containing the axles, cranks, and pulleys, and the wheel-work most directly connected with them, two brass plates, 16 inches wide and 22 inches in height, are placed in a vertical position about 2.5 inches apart, the edges of which *ab* and *a′ b′* are seen in Plate II, which is a side-view of the machine, the front being on the right. A back and front view of these plates are seen on Plates III and IV, with all unnecessary parts cut out, leaving simply a framework to support the wheels and axles. An axle for each tide-component with crank and pulley at each end, as represented in perspective at the bottom of Plate II, is supported by these plates, and is connected by wheel-work with an axle in the front part of the machine, moved by a crank at the side. This connection is such as to give the exact relative period of revolution to each axle with cranks attached.

Commencing at a small stationary pulley at *c*, Plate III, a light chain passes over the stationary pulleys *d* and *e* until it arrives at the pulley of the tide-component at *f*, and then, passing successively over all the pulleys, first up and then down, around the large central space cut out of the supporting plates, it comes to the pulley of the last component at *g*, and then, passing over several stationary pulleys, it comes to *h*, where it is connected with the upper part of the sliding frame moving vertically, a small part only of which is visible on Plate III, but is all represented in Fig. 3, Plate I. The horizontal slit in the bar of this frame determines the one side *cm* or *cm′* of the right-angled triangle, the former if the machine is set according to the amplitudes in (3) and the latter if set according to those of (6). When the pulleys are all at the center the adjustment must be so made by turning the pulley *c*, Plate III, by an arrangement for that purpose, that the height of the horizontal slit shall correspond with A_1, which is determined by means of an index attached to the chain and small scale just above *c*, not visible.

Commencing again at the point *a*, on Plate IV, which is a representation of the back brass plate and the pulleys on the cranks on the other end of the axles, a chain passes in the same manner over all the pulleys until it comes around to *b*, and then by *d* and *e* to the side of the frame sliding horizontally, only parts of which are seen on this plate, but all is seen in Fig. 3, Plate I, the connection of the chain with it being at *b* on the right of this front view of it. The slit in the vertical bar of this frame, oscillating horizontally, determines in the right-angled triangle of Fig. 2, or Fig. 3, the other side *m n* or *m′ n′* according as the machine is set to the amplitudes of N in (3) or N′ in (6). In these expressions there are no constants corresponding to A_1 in those of M and M′, and hence, when the pulleys are all thrown in to the center, the adjustment must be such that the vertical slit occupies a central position, corresponding to the point *c*, in Fig. 2, Plate I and Plate IV.

The arrangement with regard to the distances between each pulley and the two from which it is suspended is such that those belonging to the tide components K, S_2, N_2, &c., which have the largest amplitudes, are farthest from the points of suspension, so that the measurements may not be sensibly affected from a want of parallelism of the strands of chain with a vertical line. The

axles and pulleys of all the smaller tide-components are placed above with correspondingly short spaces between. The two pulleys from which S_2 is suspended are larger than the others in order that K_1, S_2, and N_2, which generally have large amplitudes, may have a wider space to swing in extreme cases.

15. The value of R in (5), (10), and (17), corresponding to *cn*, Fig. 2, Plate I, is given by the distance of chain *cn* of Plate IV. The end of a fine chain attached to the end of a pin controlled by the two sliding frames, and kept at the intersection of the two slits, and always representing the point *n* or *n'* in Fig. 2, Plate I, passes through a small eye or central hole at *c* of Plate IV, and then over several pulleys in the interior of the machine, and controls the vertical movement of the index on the left side of Plate V, which is a perspective view of the front and left side of the machine as finished. As the distance between *c* and *n* increases or decreases the index rises or falls the same amount on the scale, from which is read off the height of high or low water, the former on the left part and the latter on the right part of the scale, the negative direction of the latter being upward. As these readings are generally from some plane below mean level, as that of mean low water, which is represented by H_0 in the preceding expression of H, the zero of the left scale must be thrown down by that distance, and the other as much up. For this purpose the scales are made adjustable by means of a small toothed wheel between the scales, by which, when the left scale is thrown down, the other is thrown up just as much.

The construction of the machine is such that for tides of large range, not exceeding about 12 feet, a foot of tide corresponds to an inch of the scale. The scales, however, have a double graduation, in which in the one a foot of tides corresponds to 2 inches of the scale, so that tides of smaller range, not exceeding about 6 feet, may be read from this scale, the pulleys in this case being thrown out twice as far on the cranks for the same amplitudes. If, however, the range of the tide is very great, the half amplitudes must be used in setting, and the readings from the scale of closest graduation, must then be doubled.

16. The whole machinery is moved with the left hand by means of a crank represented on the left side of the machine in Plate V, and on the right side of Plate IV in a back view. This crank turns a horizontal axle passing from side to side, mostly visible in the lower part of the front view. By means of a connection between this axle and two upright shafts *k* and *l*, Plate III, the one on the left, *k*, is made to turn twice in a lunar day, and the one on the right, *l*, once in a lunar day. By means of a connection of three wheels and an endless screw between the shaft *k* and each of the axles of the semi-diurnal tide-components, which are all arranged on that side, each of these axles is made to turn in its proper relative period with regard to that shaft, which is given in the preceding table. The numerators and denominators of the fractions representing these relations very nearly are the number of teeth in the wheels used in making the connections, the unity of the one fraction being represented by the endless screw. The connections on the other side between *l* and each of the axles of the diurnal and other components, which are all arranged on that side, are made by means of four wheels, of which the number of teeth correspond with the numerators and denominators of the fractions, representing the relations very nearly between the motion of the upright shaft and each of the axles of the components. The relations between the proper motions of these axles and the shaft on the *other side* are given in the preceding table, and therefore to get the relations to the other shaft, since it turns only one-half as fast, the relations in the table must be doubled, which is done by omitting the fraction $\frac{1}{2}$. The parts of the true relations which are not satisfied in these connections are given by the decimal added to the other fractions in the table. The amount of error in degrees of the indices of the several components, which are represented on Plate IV, is found by multiplying these decimals into $28^\circ.984$ and the number of hours the machine has run. The amount of error for one year is given in the last column of the table. By placing the relations of the cranks for cosines and sines differently for positive and negative angles, it has been arranged to have all the indices turned in the same direction, and the signs of the errors given indicate gain or loss in the motion of the indices without regard to the signs of the original angles.

The absolute errors in the heights of the tides arising from these errors of course depend upon the amplitude of the component. In our Atlantic tides, in which the amplitudes of the solar and

all the other components except the lunar are less than 1 foot, except at Eastport, and the diurnal amplitudes everywhere are especially small, the machine might be run through ten years and the error in any one component would not amount to 1 inch in the heights of the tides, though of course the errors of several might combine and make the whole error more than that.

On the Pacific coast, where the diurnal components are very large, on account of the less accuracy of the relation in O_1, the machine could not be run nearly so long without incurring the same amount of error.

17. Just in front of the two sliding frames is a lever turning on the central point of the machine, represented by *c* in the back view of Plate IV, which contains a groove, in which one end of the pin at the intersection of the two slits of the sliding frames moves up and down and always controls its direction, so that it always has a direction corresponding to *cn* or *cn'* of Fig. 2, Plate I. By means of a connection of wheel-work the needle on the face of the dial, Plate V, always has the same direction as *cn* or *cn'* or the lever behind. Hence the angle between this needle and the vertical, which can be read in lunar time or in degrees from the graduated circles, is that corresponding to β or β' in Fig. 2, Plate I.

The index on the dial, Plate V, pointing to the left a little below the figure 9, and corresponding to *ce* in Fig. 2, Plate I, is the lunar index already explained in § 10. The other index pointing to 12, and corresponding to *cd* in Fig. 2 is the solar index, which indicates the solar time. When this points to 12, and the small index directly below the center points downward, it is midnight; but if the small index points upward, it is noon. Although the lunar index moves according to lunar mean time, yet it does not point out this time on the dial, but indicates the phases of the mean lunar tide, and the high water of this tide occurs when the index points to 12. It consequently points out the lunar time which has elapsed since the last high water of the mean lunar semi-diurnal tide.

The ratio between the motions of the solar and the lunar index is that of

$$\frac{30^{\circ}.000000}{28^{\circ}.984104}=\frac{40\times110}{39\times109}\text{ very nearly.}$$

The latter is so nearly correct that the error in the reduction of lunar to solar time amounts to only about one minute in two years. The fractions in the second number, expressing this important relation, were discovered here independently, but it was afterwards found that they had been previously discovered by Mr. Roberts. The wheel-work, with the number of the teeth corresponding to the numerators and denominators of these fractions, and by which the solar and lunar indexes are caused to have their proper relations to each other, and that by which the needle is kept parallel with the lever behind it, already explained, are partially seen in the central part of the dial of Plate V.

The longer index, in the upper left-hand corner, moves around the circle in three hundred and sixty-five days, and keeps a record of the day of the year. Between the other end of the axle which controls this index and the axle of the small toothed wheel, between the two scales on the left of the face of the machine, there is a connection by means of a small crank and a rod which turns a little the latter axle, by which the annual inequality of mean level of the sea is taken into account. During one part of the year the left scale is thrown down a little and the other up, the effect of which is to increase the readings of both high and low waters. During the other part of the year the effect is the reverse. The smaller index is used in setting the axle and crank in accordance with the epoch of maximum of this annual irregularity.

The index of this and the indices of the other three dials in the other corners are controlled by means of connections between their axles and the horizontal shaft below, which is turned directly, with the left hand, by means of the crank attached to it. The uses of the other three indices will be understood from the inscriptions on the dials.

The thermometer on the right side, Plate V, is no essential part of the machine, but is placed there because it is a convenient place to keep a thermometer to give the temperature of the room, and, also, because it gives symmetry to the face of the machine by corresponding to the scale on the right.

The whole is included within a glass case which opens in front. The whole case can also be lifted up and laid aside when it is desirable either to set the machine or for any other purpose.

DIRECTIONS FOR SETTING AND USING.

18. In the first adjustments of the machine the pulleys on the cranks must all be thrown into the center, and the vertically-oscillating frame must be let down by means of an arrangement near *c*, Plate III, until the middle of the horizontal slit coincides exactly with the center at *c*, Plate IV. The small index above *c*, Plate III, attached to the chain, must be then so adjusted that it will point to zero of the small scale belonging to it. A small screw at *a*, Plate IV, at the beginning of the other chain, should also be turned until the middle of the vertical slit coincides with the center *c*. In these adjustments there is a slight yielding of the parts with a change of tension, so that they should be made by coming to the positions from both sides and taking the mean of the small difference. These adjustments, being once made, should not require any change; but it is well to verify them occasionally, for in the use of the machine some small changes in the rigidity of the different parts might gradually take place.

In the harmonic analysis of tidal observations it is usual to give the constants of the expression of the tidal function h, in the following form:

$$h = H_o + \Sigma A_e \cos (i_e t - \varepsilon_e) \tag{a}$$

But the value of ε_e is the epoch in angle from the time of the passage of the fictitious moon of each component over the meridian, to the time of high water of that component. Hence at the time of this meridian passage we have for each component $t = 0$, or some number of even periods. In the expression of h in (1), however, we have $t = 0$, for all the components at the same time, which is usually assumed to be January 1, 0^h (leap year January 2, 0^h). The values of ε_e, therefore, in the preceding expression must be reduced to those corresponding to this epoch of $t = 0$. This reduction is made by means of equation (9), "Discussion of Tides in Penobscot Bay,"* with the values of $c_n = s\, c_e$ contained in the Table II of that paper. The following table is the latter part of that table, somewhat modified in form and notation, more convenient for practical application here, and extended to the end of the century. The constant $s\, c_e$ of that table is here denoted by k_e

Table II contains the values of the constants k_e for the several components, and also the longitude of the moon's ascending node (ω), angle of moon's phase (a), the moon's mean anomaly (b), and the angle of the moon's place from the equatorial node (c), for the first of each year. The values of k_e for the shallow-water components are, for $(MS)_4$, equal to k_1, for M_4, equal to $2\, k_1$, and for M_6, equal to $3\, k$, k_1 being the value of k_e for the component M_2. For the solar component it is equal 0.

TABLE II.

Year.	M_2	K_2	L_2	N_2	λ_2	ν_2	μ_2	τ_2	U_2	K_1	O_1	P_1	Q_1	Q'_1	ω	a	b	c
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1880	243.6	202.4	162.2	324.8	81.2	45.8	127.2	359.6	6.0	11.2	232.3	348.8	313.6	92.5	285.9	238	279	169
1881	344.3	202.8	351.8	336.8	352.6	336.0	328.6	359.9	119.2	11.0	333.3	349.0	325.9	3.6	266.6	8	7	301
1882	85.1	201.4	181.2	348.8	263.8	266.2	170.2	0.2	232.5	10.7	74.3	349.2	338.1	274.5	247.2	137	96	68
1883	185.8	201.0	10.8	1.0	175.0	196.6	11.6	0.4	345.5	10.5	175.3	349.5	350.4	185.6	227.9	267	185	196
1884	262.2	202.4	188.8	335.4	73.4	91.0	164.4	359.6	35.2	11.2	250.9	348.7	324.3	84.6	208.5	49	287	334
1885	3.0	202.0	18.4	347.6	344.6	21.2	5.8	359.9	148.5	11.0	351.9	349.0	336.5	355.6	189.2	179	15	100
1886	103.7	201.6	207.8	359.6	255.8	311.5	207.4	0.2	261.7	10.8	92.9	349.2	348.8	266.7	169.9	308	104	227
1887	204.4	201.0	37.3	11.6	167.2	241.8	48.9	0.5	14.9	10.5	193.9	349.5	1.1	177.7	150.5	178	193	353
1888	280.8	202.6	215.4	346.2	65.4	136.2	201.6	359.8	64.4	11.3	269.5	348.7	334.9	76.6	131.2	220	295	133
1889	21.6	202.0	45.0	358.2	336.6	66.4	43.1	0.0	177.7	11.0	10.5	349.0	347.2	347.7	111.8	349	23	260
1890	122.3	201.6	234.4	10.2	248.0	356.8	244.6	0.2	291.0	10.8	111.5	349.2	359.4	258.1	92.5	119	112	28
1891	223.0	201.0	63.8	22.3	159.3	287.0	86.1	0.5	44.1	10.5	212.5	349.5	11.7	169.7	73.1	348	201	159
1892	299.4	202.6	242.0	356.9	57.5	181.4	238.8	359.8	93.6	11.3	288.1	348.7	345.6	68.6	53.8	30	302	304
1893	40.2	202.0	71.6	8.9	328.7	111.6	80.3	0.0	206.9	11.0	29.1	349.0	357.8	339.7	34.4	159	31	76
1894	140.9	201.7	261.0	20.9	240.1	42.0	281.8	0.2	320.2	10.8	130.1	349.2	10.1	250.1	15.1	290	120	209
1895	241.6	201.2	90.4	33.0	151.4	332.2	123.3	0.5	73.3	10.5	231.1	349.5	22.4	161.7	355.7	159	209	340
1896	318.0	202.9	268.6	7.6	49.6	226.6	176.0	359.8	122.8	11.4	306.7	348.7	356.2	60.6	336.4	201	311	126
1897	58.8	202.3	98.2	19.5	320.8	156.8	117.5	0.0	236.1	11.1	47.7	349.0	8.5	331.7	317.0	331	39	259
1898	159.5	201.8	287.6	31.5	232.2	87.2	319.0	0.2	349.4	10.9	148.7	349.2	20.7	242.2	297.7	100	128	31
1899	260.2	201.3	117.0	43.6	143.5	17.4	160.5	0.5	102.5	10.6	249.7	349.5	33.0	153.7	278.3	330	217	161
1900	336.6	203.0	295.2	18.2	41.7	271.8	213.2	359.8	152.0	11.5	325.3	348.7	6.9	52.6	259.0	12	318	303

* Appendix 11, Report for 1878.

Designating by ϵ'_e the value of ϵ_e with the preceding reductions applied, instead of (a) we have

(b) $$h = \mathrm{H}_0 + \Sigma\, \mathrm{A}_e \cos\,(i_e\, t - \epsilon'_e)$$

in which

(c) $$\epsilon'_e = \epsilon_e - k_e$$

19. In the four components M_2, K_2, K_1, and O_1 it is usual to combine with each the small component of nearly the same period, referred to in § 12, and use through the year the amplitude and epoch of the resultant for the middle of the year. From the amplitude and epoch of the principal component, those of the resultant are obtained by multiplying the former by the factor F, and adding to the latter the correction $\delta\epsilon$ contained in the following table.

TABLE III.—*Containing the factors F, and the corrections $\delta\epsilon_e$ used in reductions of M_2, K_2, K_1, and O_1.*

Argument ω	The factors F.				Corrections $\delta\epsilon$.				Argument ω
	M_2.	K_2.	K_1.	O_1.	M_2.	K_2.	K_1.	O_1.	
°					°	°	°	°	°
0	0.964	1.28	1.14	1.22	± 0.0	± 0.0	± 0.0	∓ 0.0	360
10	0.964	1.28	1.13	1.22	0.4	2.2	1.2	1.8	350
20	0.966	1.27	1.13	1.21	0.7	4.4	2.3	3.6	340
30	0.969	1.26	1.12	1.20	1.1	6.5	3.4	5.3	330
40	0.973	1.23	1.11	1.18	1.4	8.6	4.5	6.9	320
50	0.977	1.20	1.09	1.15	1.6	10.5	5.4	8.4	310
60	0.981	1.17	1.07	1.13	1.8	12.2	6.2	9.8	300
70	0.987	1.13	1.05	1.10	2.0	13.7	6.8	10.9	290
80	0.995	1.10	1.03	1.06	2.0	15.0	7.3	11.8	280
90	1.000	1.05	1.00	1.03	2.1	16.0	7.6	12.4	270
100	1.007	1.00	0.99	0.99	2.0	16.5	7.7	12.7	260
110	1.013	0.94	0.96	0.95	1.9	16.6	7.5	12.6	250
120	1.019	0.89	0.94	0.91	1.7	16.1	7.1	12.1	240
130	1.024	0.85	0.92	0.87	1.5	15.0	6.4	11.1	230
140	1.028	0.80	0.90	0.84	1.3	13.2	5.5	9.7	220
150	1.031	0.76	0.89	0.82	1.0	10.7	4.4	7.7	210
160	1.034	0.74	0.87	0.79	0.7	7.6	3.0	5.4	200
170	1.035	0.72	0.87	0.78	0.3	4.0	1.6	2.8	190
180	1.036	0.71	0.87	0.78	± 0.0	± 0.0	± 0.0	∓ 0.0	180

The argument ω in this table must be obtained from Table II for the middle of the year, and when this argument is found on the left in this table the upper one of the double signs must be used, but if the argument is found on the right, the lower sign must be used.

The amplitudes of these four components must be multiplied into the factor F in this table, and to the epochs must be added the corrections $\delta\epsilon$, before being used in b and c, or in the following equations (d) and (e).

20. In (1) the constant of the angle is positive, and is the value of the angle when $t = 0$. This is, therefore, the most convenient form to be used in the machine. In order to have (b) in that form, it is necessary to put $c_e = -\epsilon'_e$, and we then get instead of (b)

(d) $$h = \mathrm{H}_0 + \Sigma\, \mathrm{A}_e \cos\,(it + c_e)$$

in which

(e) $$c_e = k_e - \epsilon_e$$

With the values of A_e and ϵ_e in these expressions, obtained from the analysis of observations, and corrected by means of Table III, for the components M_2, K_2, K_1, and O_1, and with the values of $i_e : i_1$ in Table I, we obtain the values of $\mathrm{A}_e \dfrac{i_e}{i_1}$ and from (3_4) the values of C_e, contained in (3) and (6), to which the machine has to be set.

The following is an example of the method of obtaining these constants for the year 1886.

The values of A_e and ε_e are those of the tides of Port Townsend, Washington Territory, obtained from an analysis of the observed hourly co-ordinates for three years, and with the corrections of Table III applied. The values of k_e are taken from Table II for each component. The values of c_e are then given by (e).

Component.	A_e.	$i_e : i_1$.	$A_e \frac{i_e}{i_1}$.	ε_e.	k_e.	c_e.	C_e.
				°	°	°	°
M_2	2.30	1.000	2.30	108.5	103.7	355.2	0
S_2	0.55	1.035	0.57	129.5	0.0	230.5	235.3
K_2	0.11	1.037	0.11	132.1	201.6	69.5	74.3
L_2	0.09	1.018	0.09	340.8	207.8	227.0	231.8
N_2	0.45	0.980	0.44	80.4	359.6	279.2	284.0
κ_2	0.09	0.983	0.09	86.0	311.5	225.5	330.3
ν_2	0.08	0.957	0.08	358.3	207.4	209.1	213.9
K_1	2.15	0.519	1.17	148.6	10.8	222.2	227.0
O_1	1.10	0.481	0.53	131.0	92.9	321.9	326.7
P_1	0.77	0.516	0.39	146.7	349.2	202.5	207.3
Q_1	0.30	0.462	0.14	122.3	348.8	226.5	231.3
Q'_1	0.22	0.500	0.11	139.8	266.7	....	....
M_4	0.12	2.000	0.24	296.7	207.4	270.7	275.5

The whole reduction above is carried out completely, but it is seen that the result would be practically the same if unity had been used for $i_e : i_1$ in the semi-diurnal components and $\frac{1}{2}$ in the diurnal components. If the machine is set according to A_e, this will answer in (6) for the times of high water, in all the semi-diurnal components.

21. Besides the preceding reductions, there is also another one necessary for many tide-stations, referred to and explained in § 9, in order to get the best results. This, as we have seen, requires the amplitudes, except A_1, to be diminished a little in (3) and to be increased as much in (6). The amount of this decrease and increase at Boston Harbor, and Penobscot Bay, and probably along the whole New England coast, is about one-sixth or one-seventh of the whole amplitude; but at New York Harbor it is one-eighth, and on the California coast still less.

22. With the constants thus obtained the machine must be set according to the different types or forms of the tide at the several stations. For the large range tides of our Atlantic coast with small diurnal components, the pulleys are thrown out on the cranks according to the formula of (19), making small corrections in the values of A_e, for the effects of friction explained in the preceding paragraph, where this is known. The indexes at the back part of the machine must be set according to the values of C_e, or their supplements for those components in which the angles, in Table I, § 12, increase negatively, for reasons given. For the amplitude A_1 of the mean lunar and principal component the machine is set by turning a milled head at the side of the machine just above c, Plate III, until the index on the chain stands on the scale at a point corresponding to the value of this amplitude. The horizontal slit in the frame oscillating vertically then stands at that height above the central part of the machine, which corresponds to the mean level of the tide. The lunar index, on the face of the machine, must be set to the degree corresponding to c_1. The solar index must be moved to the figure 12 on the dial, and the small index below must be turned down to midnight. The index in the upper left-hand corner must be placed at January 1. The small index on the same dial must be set to the supplement of the angle ε in the annual inequality of mean level. For instance, if $\varepsilon = 270°$, it must point to about the 1st of April. The other indices in the other three corners, showing the angle of phase, the moon's mean anomaly, and angle of moon's place from the equatorial node, can be set approximately by the last three columns of Table II. These require little accuracy, since the results do not depend upon them. While the machine is being set the two upright shafts, one on each side, must be clamped by means of the milled heads, for that purpose, in order to keep every part in position, as set, while this is being done.

23. The machine being thus set (which requires about one hour), and placed on the top of a desk, with blanks in front for recording the results in a form ready for the printer, and the clamps

on the sides having been loosened, you first turn the crank with your left hand until the lunar index comes in conjunction with one end of the needle. If this is the upper end, the solar index then points out the time of the first high water, and the index on the left-hand side of the face of the machine, read off on the left part of the scale, gives the height of this high water. Then turn until the lunar index comes in conjunction with the lower end of the needle. This is the time of the next low water. The solar index then points out the time of this low water, and the index on the side, read off now from the right-hand part of the scale, gives the height of this low water. Then turn until the lunar index comes in conjunction again with the upper end of the needle. This is the time of the second high water, the times and heights of which are read off as before. Continue thus through the year from high to low and from low to high water, reading off and recording the results as read off.

Where the range of the mean tide is less than about 5 feet, as is the case mostly on all stations south of Cape Cod, the pulleys on the cranks can be thrown out to double the distance of the amplitudes, and the heights then read from the inner graduation of the scales, which is 2 inches of the scale to a foot of tide.

24. Where the tide has large diurnal components in comparison with the semi-diurnal, such as to make the errors according to (21) too large, as may be the case in the tides of the Gulf of Mexico or the Pacific coast, set the machine first in accordance with formula (6) and run through for a year, reading and recording the times only of high and low waters. Then set according to (3), which requires, unless great accuracy is wanted, merely the changing of the amplitudes of the diurnal and quarter-diurnal, &c., components. Turn the crank then until a conjunction of the lunar index with the needle takes place, and observe the time from the solar index. Then turn, forward or back as the case may be, until the time pointed out by the solar index is that half way between this time and the recorded time of high water, and then read off the height of high or low water, as the case may be, from the scale on the left, and make the record. Continue this through the year.

In all cases the values of the constants, C_e, should be determined for both the beginning and end of the year, and after running through, it should be observed whether the indices stand in accordance with the values of C_e at the end of the year. If not, either the index was not set right at the start or there has been some slip, and it will be necessary to go over it again.

25. Where the diurnal components are small, as in the Atlantic tides, the upper end of the needle has an irregular half-monthly oscillation about the figure 12 on the dial, being sometimes on the one side and at others on the other. This answers to the half-monthly inequality in the times. There is a corresponding inequality in the height of the index on the left of the face, indicating a similar inequality in the heights. There is also, in connection with this inequality, a small diurnal inequality of both the times and heights, indicated by the motion of the needle and the index on the scale.

If the diurnal components are large, there is a large oscillation of the needle from one side to the other and back every day, corresponding to the diurnal inequality in the times, and also a large vertical oscillation of the index at the side, corresponding to the alternate higher and lower high or low waters of the same day.

Where the diurnal components are so large as to cause the movable point n, Fig. 2, Plate I, to come around below the center c in the second setting in which the heights are read, the height of one high water may fall below, or of one low water above, mean sea level. The value of $(\beta-\beta')$ then in the table of the Appendix becomes greater than 90°, and the term R cos $(\beta-\beta')$ given in the table has the contrary sign and must be applied to H_0 accordingly.

Where the amplitudes of the diurnal components are so large as to bring the point n around below c in the first setting, the needle is made to move entirely around each day, and there can be only two conjunctions of the lunar index with the needle in a day, one with each end. There is in this case only one high and one low water each day.

There is one critical case in which the machine fails. This is where the point n would pass exactly through the point c. This is a case which sometimes occurs, and a little aid is then required

to help it pass. This occurs mostly when the large diurnal tide brings one of the high waters down to about mean tide level. The wave is then very flat and the times from observation, and as given by the machine, are both somewhat uncertain.

EFFICIENCY OF THE MACHINE.

26. The results given by the machine have been compared with both computation and observation. In a comparison with computation for one month of the tides of Boston Harbor the difference in the heights rarely amounted to more than 0.1 foot, and in the times, to more than three or four minutes. These arise from a slight yielding of some parts of the machine with increase or decrease of tension in the chains over the pulleys on account of the axles and cranks not having quite rigidity enough. This, however, could be remedied by making the axles and cranks of the larger components, which have to do the most work, a little stronger. In all short-range tides, which can be worked on the scale of 2 inches to the foot of tide, these defects are diminished one-half, and in no case are they of any consequence in comparison with the various abnormal disturbances of changes of winds and barometric pressure, which cannot be taken into account.

In a comparison of the results given by the machine for three months of the tides of San Diego, with the times and heights as given by observation, the average of the differences in the times and the heights taken without regard to signs were as follows:

	Times.	Heights.
	Minutes.	*Feet.*
January	11	0.28
February	8	0.33
March	12	0.25
Mean	10	0.29

Of course these differences are due mostly to the meteorological disturbances, and only in a small measure to the errors of the machine. The comparisons, also, are for the winter months, in which these abnormal disturbances are always found to be the greatest.

The averages of the differences in the times are very much increased on account of the large diurnal tide, making the tide-wave often very flat at the times of one of the high and low waters of the day, when the exact times of maxima and minima become very uncertain.

The machine has also been tested in its application to the very singular tides of Papeete, of the island of Tahiti, in which the times of high water sometimes follow the moon, as usual, but at other times the sun. An explanation of these tides has been given in my Tidal Researches, published as a separate appendix to the Coast Survey Report for 1874. The observations of these tides extend only from the 1st of June, 1856, until about the middle of October. The peculiarity of these tides consists in the solar semi-diurnal tide being in general larger than the lunar. During the month of June, with maximum declination of the sun, this tide, however, was a little less, and then the times were controlled by the lunar tide, and the times of high water followed, though at very irregular intervals, the moon. In July, however, and especially about the time of the autumnal equinox, the solar tide became larger than the lunar, so that the point n, Fig. 2, Plate I, passed around c, carrying the needle around with it in such a manner as to cause the times of high water, as read off from the solar index, to fall all the time at nearly the same hours of the day, and soon after 12 of noon and midnight. The heights, as read off, were a maximum, as they should be, near the times of the syzigies, but nearly vanished at the quadratures.

The machine is now being used in the prediction of the tides for the year 1885 to be used in the Tide Tables, published annually by the Coast and Geodetic Survey, and, with the exception of the very small defects referred to, is found to give entire satisfaction.

The capacity of the machine for doing work is at least that of 30 or 40 computers, if these were to take into account everything which the machine does.

APPENDIX.

By Mr. L. P. Shidy.

[Containing table of the product $R \cos (\beta - \beta')$ of the formula (10) $H - H_0 \pm R \cos (\beta - \beta')$ which is to be used where it is necessary to use formula (10), as occurs in some rare cases. The upper sign is used for high and the lower one for low waters. H = the required height, H_0 = difference between plane of reference and mean sea level. R = difference between center of small cog-wheel and position of pointer on height scale. β = reading needle, and β' = lunar hand.]

R in Feet.	± (β − β′).													
	20°.	25°.	30°.	35°.	40°.	45°.	50°.	55°.	60°.	65°.	70°.	75°.	80°.	85°.
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
0.2	.2	.2	.2	.2	.2	.1	.1	.1	.1	.1	.1	.1	.0	.0
0.3	.3	.3	.3	.3	.2	.2	.2	.2	.2	.1	.1	.1	.1	.0
0.4	.4	.4	.4	.3	.3	.3	.3	.2	.2	.2	.1	.1	.1	.0
0.5	.5	.5	.4	.4	.4	.4	.3	.3	.3	.2	.2	.1	.1	.0
0.6	.6	.5	.5	.5	.5	.4	.4	.3	.3	.3	.2	.2	.1	.1
0.7	.7	.6	.6	.6	.5	.5	.5	.4	.4	.3	.2	.2	.1	.1
0.8	.8	.7	.7	.7	.6	.6	.5	.5	.4	.3	.3	.2	.1	.1
0.9	.8	.8	.8	.7	.7	.6	.6	.5	.5	.4	.3	.2	.2	.1
1.0	.9	.9	.9	.8	.8	.7	.6	.6	.5	.4	.3	.3	.2	.1
1.1	1.0	1.0	.9	.9	.8	.8	.7	.6	.6	.5	.4	.3	.2	.1
1.2	1.1	1.1	1.0	1.0	.9	.9	.8	.7	.6	.5	.4	.3	.2	.1
1.3	1.2	1.2	1.1	1.1	1.0	.9	.8	.7	.7	.5	.4	.3	.2	.1
1.4	1.3	1.3	1.2	1.1	1.1	1.0	.9	.8	.7	.6	.5	.4	.2	.1
1.5	1.4	1.4	1.3	1.2	1.2	1.1	1.0	.9	.8	.6	.5	.4	.3	.1
1.6	1.5	1.5	1.4	1.3	1.2	1.1	1.0	.9	.8	.7	.6	.4	.3	.1
1.7	1.6	1.5	1.5	1.4	1.3	1.2	1.1	1.0	.9	.7	.6	.4	.3	.2
1.8	1.7	1.6	1.6	1.5	1.4	1.3	1.2	1.0	.9	.8	.6	.5	.3	.2
1.9	1.8	1.7	1.6	1.6	1.5	1.3	1.2	1.1	1.0	.8	.7	.5	.3	.2
2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.0	.9	.7	.5	.4	.2
2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.3	1.2	1.1	.9	.7	.5	.4	.2
2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.4	1.3	1.1	.9	.8	.6	.4	.2
2.3	2.2	2.1	2.0	1.9	1.8	1.6	1.5	1.3	1.2	1.0	.8	.6	.4	.2
2.4	2.3	2.2	2.1	2.0	1.8	1.7	1.5	1.4	1.2	1.0	.8	.6	.4	.2
2.5	2.3	2.3	2.2	2.1	1.9	1.8	1.6	1.4	1.3	1.1	.9	.7	.4	.2
2.6	2.4	2.4	2.2	2.1	2.0	1.8	1.7	1.5	1.3	1.1	.9	.7	.5	.2
2.7	2.5	2.4	2.3	2.2	2.1	1.9	1.7	1.6	1.4	1.1	.9	.7	.5	.2
2.8	2.6	2.5	2.4	2.3	2.1	2.0	1.8	1.6	1.4	1.2	1.0	.7	.5	.2
2.9	2.7	2.6	2.5	2.4	2.2	2.1	1.9	1.7	1.5	1.2	1.0	.8	.5	.3
3.0	2.8	2.7	2.6	2.5	2.3	2.1	1.9	1.7	1.5	1.3	1.0	.8	.5	.3
3.1	2.9	2.8	2.7	2.5	2.4	2.2	2.0	1.8	1.6	1.3	1.1	.8	.5	.3
3.2	3.0	2.9	2.8	2.6	2.5	2.3	2.1	1.8	1.6	1.4	1.1	.8	.6	.3
3.3	3.1	3.0	2.9	2.7	2.5	2.3	2.1	1.9	1.7	1.4	1.1	.9	.6	.3
3.4	3.2	3.1	2.9	2.8	2.6	2.4	2.2	2.0	1.7	1.4	1.2	.9	.6	.3
3.5	3.3	3.2	3.0	2.9	2.7	2.5	2.3	2.0	1.8	1.5	1.2	.9	.6	.3
3.6	3.4	3.3	3.1	2.9	2.8	2.5	2.3	2.1	1.8	1.5	1.2	.9	.6	.3
3.7	3.5	3.4	3.2	3.0	2.8	2.6	2.4	2.1	1.9	1.6	1.3	1.0	.6	.3
3.8	3.6	3.4	3.3	3.1	2.9	2.7	2.4	2.2	1.9	1.6	1.3	1.0	.7	.3
3.9	3.7	3.5	3.4	3.2	3.0	2.8	2.5	2.2	2.0	1.6	1.3	1.0	.7	.3
4.0	3.8	3.6	3.5	3.3	3.1	2.8	2.6	2.3	2.0	1.7	1.4	1.0	.7	.3
4.1	3.9	3.7	3.6	3.4	3.1	2.9	2.6	2.4	2.1	1.7	1.4	1.1	.7	.4
4.2	3.9	3.8	3.6	3.4	3.2	3.0	2.7	2.4	2.1	1.8	1.4	1.1	.7	.4
4.3	4.0	3.9	3.7	3.5	3.3	3.0	2.8	2.5	2.2	1.8	1.5	1.1	.7	.4
4.4	4.1	4.0	3.8	3.6	3.4	3.1	2.8	2.5	2.2	1.9	1.5	1.1	.8	.4
4.5	4.2	4.1	3.9	3.7	3.4	3.2	2.9	2.6	2.3	1.9	1.5	1.2	.8	.4

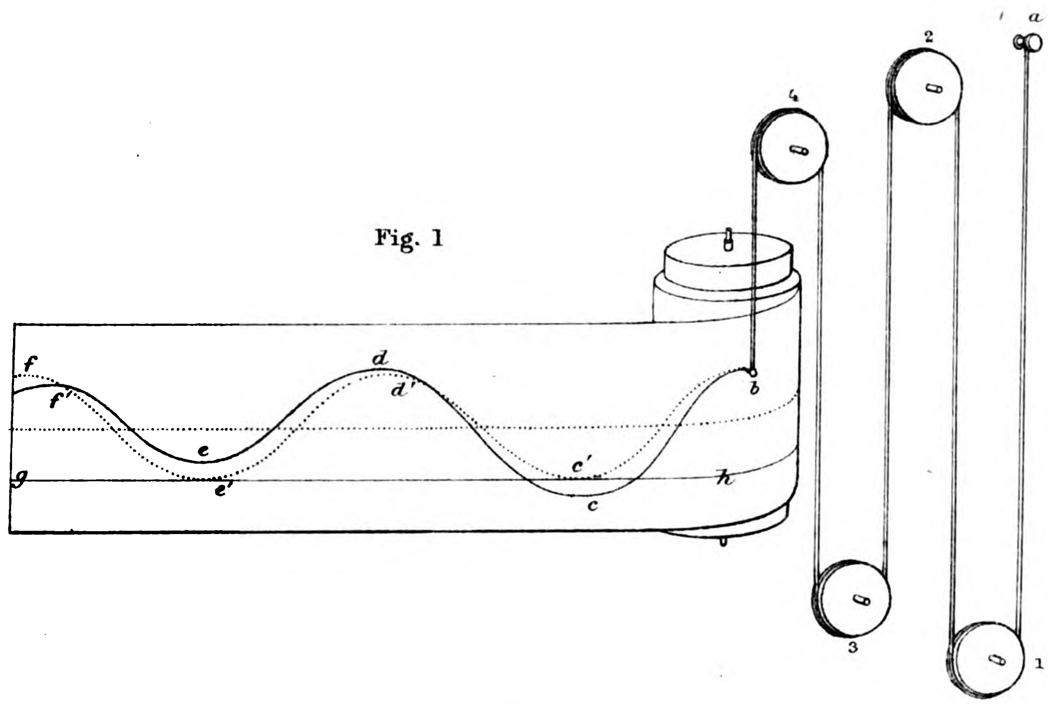


Fig. 1

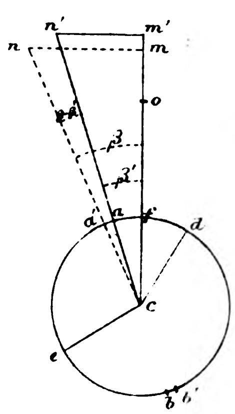


Fig. 2

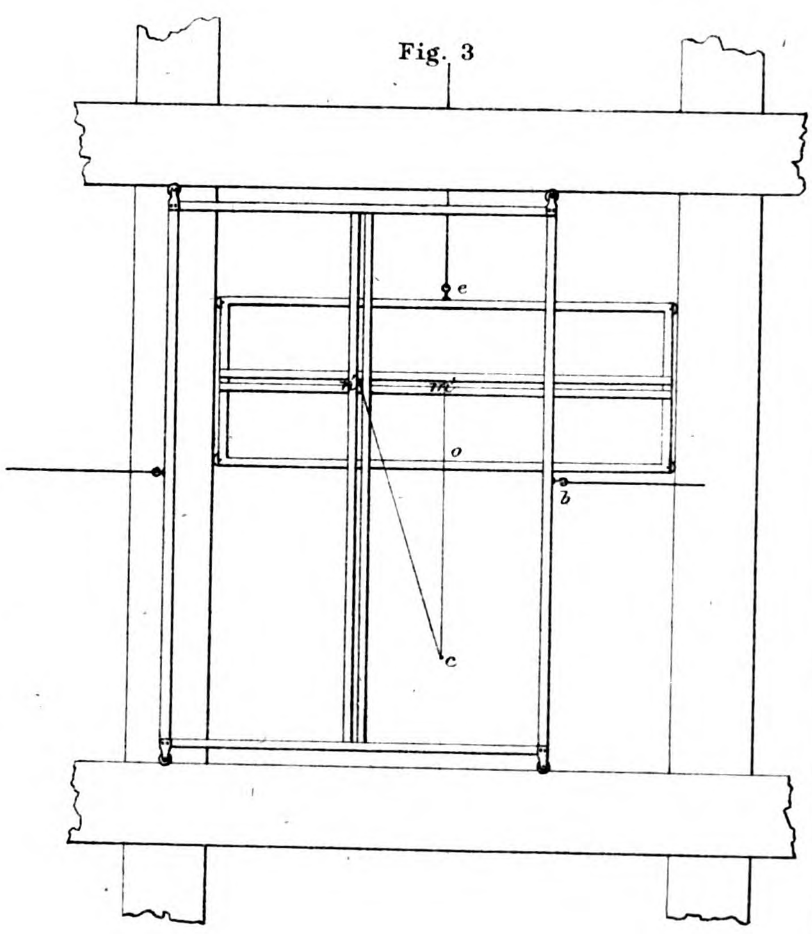
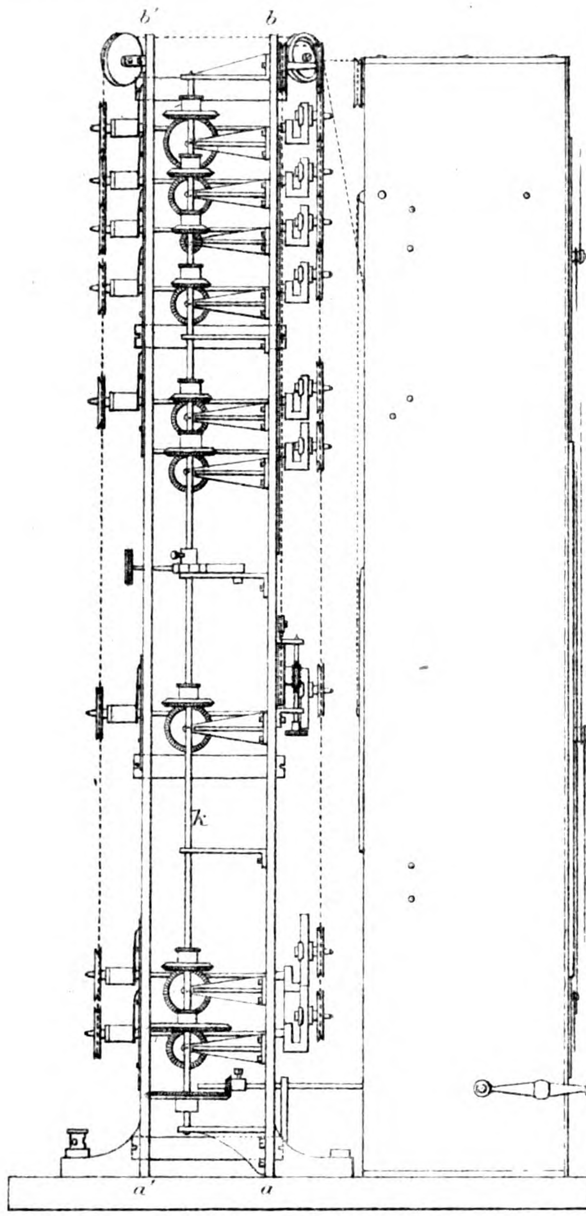
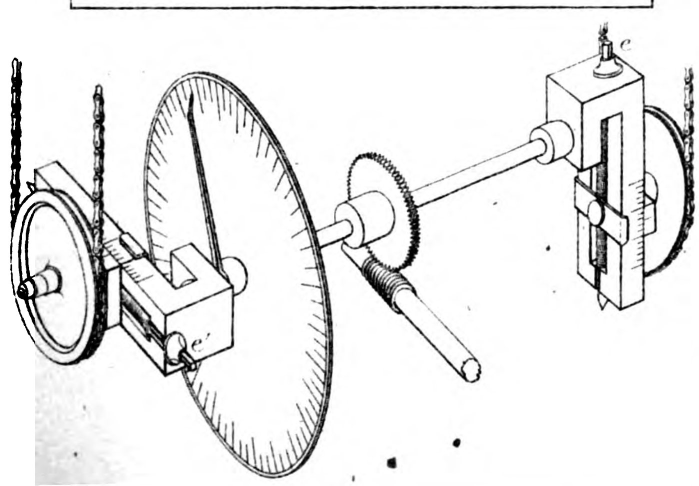


Fig. 3

PLATE I





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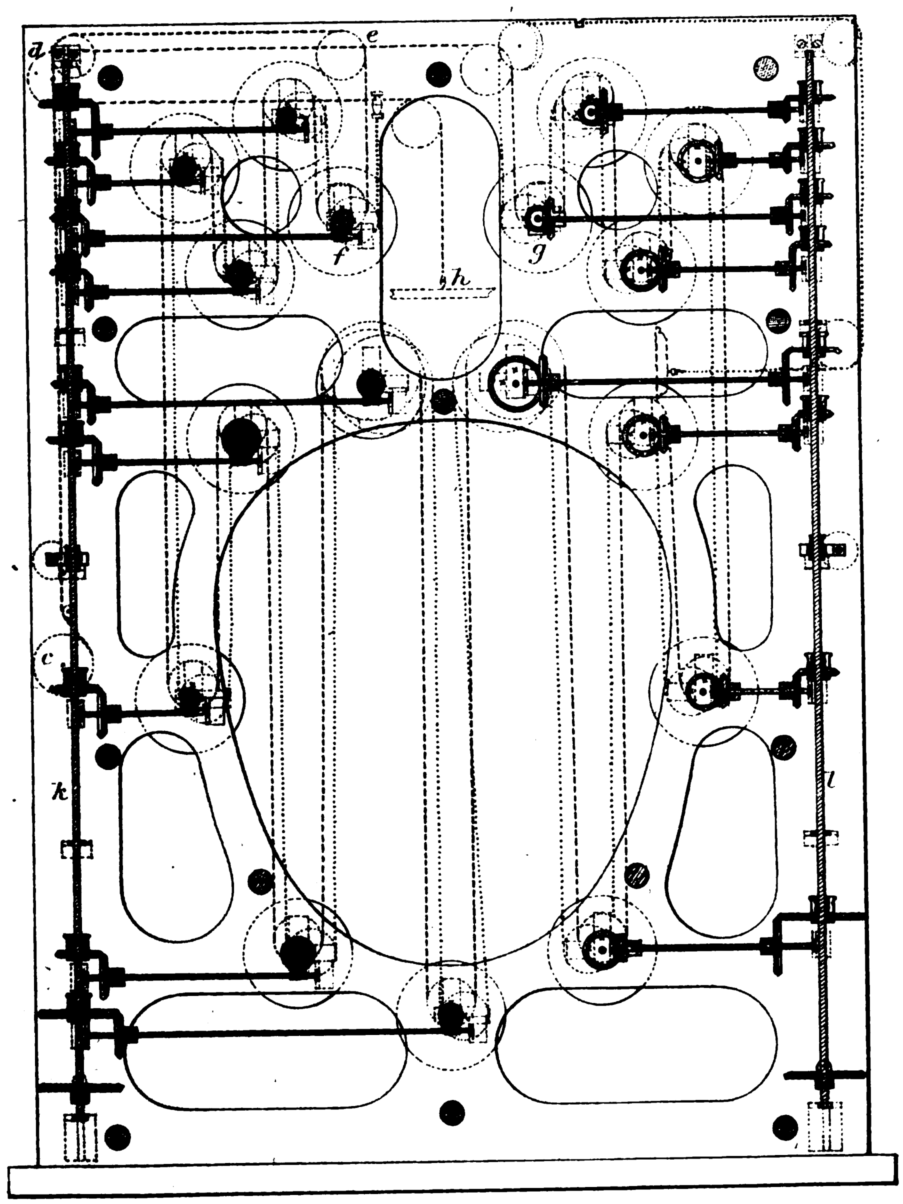

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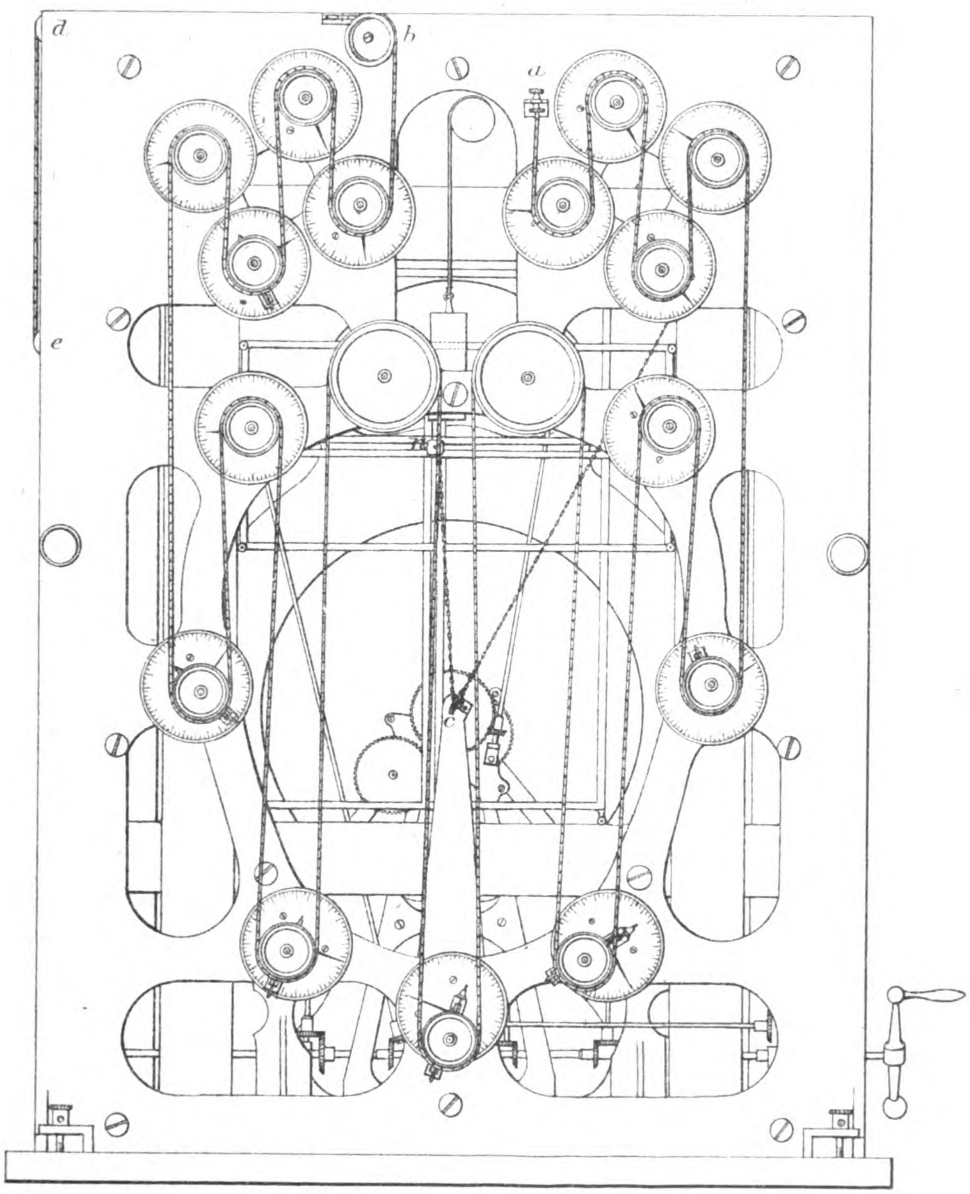


PLATE IV

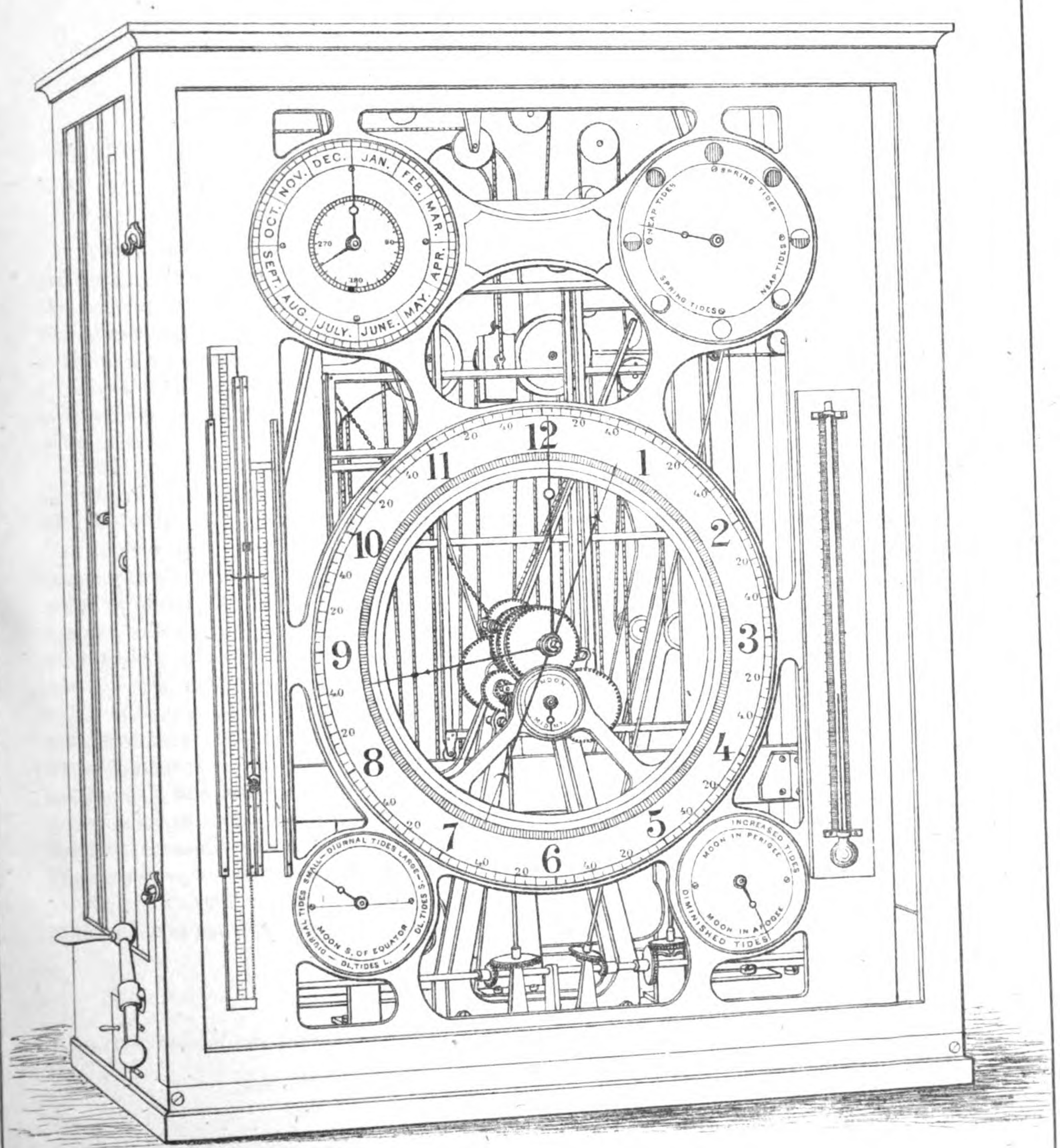

JAN.
FEB.
MAR.
APR.
MAY.
JUNE.
JULY.
AUG.
SEPT.
OCT.
NOV.
DEC.
SPRING TIDES
NEAP TIDES
INCREASED TIDES
MOON IN PERIGEE
MOON IN APOGEE
DIMINISHED TIDES
DIURNAL TIDES SMALL
DIURNAL TIDES LARGE
MOON S. OF EQUATOR

PLATE V

APPENDIX No. 11.

RESULTS FOR THE LENGTH OF THE PRIMARY BASE-LINE IN YOLO COUNTY, CALIFORNIA, MEASURED IN 1881 BY THE PARTY OF GEORGE DAVIDSON, ASSISTANT.

Computation and Discussion of Results, by CHARLES A. SCHOTT, Assistant.

A full account of the measurement of the Yolo base and of the construction and description of the apparatus used has been given in Appendices Nos. 7 and 8 to the report for 1882; the first by the present writer, on the apparatus used; the second by Assistant George Davidson on the operation of measure. To these the reader may be referred once for all. The paper herewith presented contains a condensed account of the results reached by the computer for the length of the base, with a discussion of its probable error and other matter of interest connected therewith, and forms part of a series of reports* on the measure and length of the primary base lines of the Coast and Geodetic Survey.

The site of the base is in Yolo County, California, about 28 kilometers (or $17\frac{1}{2}$ statute miles) to the westward of Sacramento City; the astronomical latitude of its southern terminus is 38° 31′ 34″.19 ± 0″.07, and of its northern terminus 38° 40′ 37″.23 ± 0″.07; the astronomical azimuth of the line at Southeast base is 163° 07′ 13″.45 ± 0″.18 and that at Northwest base 343° 05′ 02″.37 ± 0″.14, making the base inclined to the meridian at its middle point about 16° 53′.9. The longitude of this point is about 121° 49′.7. The length of the line is about 17.5 kilometers (or a little short of 11 statute miles); the ground at Southeast base is about 21.6 meters (or 71 feet), and at Northwest base about 46.6 meters (or 153 feet) above the mean tidal level of the Pacific Ocean. The soil is a rich, dark loam, more sandy near Southeast base and stiff clay near Northwest base; the grade is very easy, almost level, except when nearing the upper end, where for about 100 meters the ascending slope is about 4°; the maximum inclination of a bar was 5° 21′.5. Underneath the monuments marking the ends of the base there are granite blocks; inserted in these a copper bolt, with a fine drill hole in its upper surface, defines the terminus of the base at each end. The line was measured twice and in opposite directions, and some parts of it thrice; the time spent in the first measure was twenty days, in the second eighteen, and in the third eight working days. The measurement commenced September 19 and was completed November 24, 1881.

In the annual report for 1882, Appendix No. 7, there is given an account of the construction of the base apparatus and of the standard bars and the length of the field standard is shown to be

$$\begin{array}{l} 5\text{m} + 1163^{\mu}.0 + 57^{\mu}.47\ (t - 17^{\circ}.07\ \text{C}) \\ \quad\quad\ \ \pm 2\ .1\quad \pm\ .21 \end{array}$$

Also the value of *one turn* of Fauth & Co.'s screw contact-level comparators III and IV, viz:

$$\begin{array}{l} 254^{\mu}.528 + 0^{\mu}.002\ (t - 20^{\circ}\text{C}) \\ \quad \pm 10 \end{array} \quad \text{and} \quad \begin{array}{l} 254^{\mu}.535 + 0^{\mu}.002\ (t - 20^{\circ}\text{C}) \\ \quad \pm 9 \end{array}$$

respectively. In these expressions μ stands for a micron or the millionth part of a meter, C indicates centigrade thermometric scale, and the quantity following the plus or minus sign the probable error of the respective quantity above it. We also transcribe from the same appendix the

*The last of these published forms Appendix No. 12, Report for 1873, on the length of the Peach Tree Ridge base, in Georgia, 1872.

table of corrections to the graduation of the mercurial inclined thermometers attached to the standard and the bars, viz:

Temperature.	Thermometers of standard.		Thermometers of bar 1.		Thermometers of bar 2.	
	4518.	4520.	4522.	4523.	4524.	4525.
° C.	°	°	°	°	°	°
43	−.33	−.36	−.36	−.40	−.34	−.34
38	.26	.28	.28	.26	.26	.29
32.5	.30	.30	.33	.24	.24	.32
27	.28	.29	.30	.24	.20	.30
21.5	.18	.13	.19	.18	.13	.20
16	.16	.11	.23	.16	.13	.12
10	.16	.06	.15	.16	.06	.12
4.5	−.06	−.02	−.08	−.11	−.07	−.10

The highest temperature during which a bar was laid was 32°.4 C. (September 30) and the lowest 3°.0 C. (November 22); for the *outer* air (in the shade) these extremes were of course much exceeded.

As already stated, the unit of length upon which the geodetic work of the Survey depends is the iron committee meter of 1799, the property of the American Philosophical Society, at Philadelphia; the length of the 5-meter field standard is given in terms of this meter. It will be easy hereafter to express our lengths in terms of the new international meter as soon as the latter shall have been distributed and compared; in the mean time, if desirable, we may refer to the late direct comparison* of the committee meter with the platinum meter of the Conservatoire at Paris, in August, 1867.

For an investigation of the permanency of the indications of the Borda scales attached to the office and field 5-meter standards, see *Addendum* (*A*) at the close of this report.

LENGTH OF THE BASE-BARS 1 AND 2.

The length of the base will be made to depend upon the length of the base-bars as derived directly from their comparisons with the field standard made every morning before commencing the measure on the base. Generally two sets of comparisons were made, and these at a time when the bars had arrived at or near their daily minimum temperature, as indicated by the mercurial thermometers. This happened near the hours of 7 and 8 a. m.

The results of these comparisons are given in the following table:

Daily results for length of base-bars = 5 meters + tabular quantity in microns.

1881.	Time. a. m.	Corrected temperature. Standard.	Corrected temperature. Bar 1.	Corrected temperature. Bar 2.	Length of Bar 1.	Length of Bar 2.	1881.	Time. a. m.	Corrected temperature. Standard.	Corrected temperature. Bar 1.	Corrected temperature. Bar 2.	Length of Bar 1.	Length of Bar 2.
	h. m.	° C.	° C.	° C.	μ.	μ.		h. m.	° C.	° C.	° C.	μ.	μ.
Sept. 18	6 47	18.2	14.2	14.9	+30.5	+304.7	Oct. 7	8 02	16.0	15.7	15.8	+75.1	+350.5
18	7 45	17.7	14.4	15.2	45.8	312.0	Oct. 8	7 30	13.2	11.6	11.7	56.0	341.0
Mean...	7 16	18.0	14.3	15.0	38.2	308.4	8	8 00	13.3	12.0	12.2	61.4	340.8
Sept. 19	8 55	16.3	13.4	13.7	47.0	293.1	Mean...	7 45	13.2	11.8	12.0	58.7	340.9
22	8 36	19.5	17.2	17.1	55.1	311.0	Oct. 10	7 30	13.7	11.4	11.6	38.1	337.9
24	7 58	13.7	12.5	12.6	43.7	303.3	10	7 45	13.7	11.6	11.9	52.1	353.9
27	8 00	15.4	14.0	14.3	59.2	332.5	Mean...	7 38	13.7	11.5	11.8	45.1	345.9
28	8 51	17.6	16.9	17.2	63.8	324.9	Oct. 11	7 40	18.4	16.9	16.9	46.7	338.6
29	7 25	16.0	14.9	15.0	46.6	315.1	11	8 00	18.4	17.0	17.1	46.2	340.6
30	7 25	15.7	13.1	13.5	49.9	323.8	Mean...	7 50	18.4	17.0	17.0	46.4	339.6
Oct. 1	7 00	17.1	14.3	13.9	31.4	311.1	Oct. 12	8 00	11.4	10.2	10.4	71.7	336.6
3	9 08	17.5	16.2	16.3	62.0	317.8	12	8 15	11.6	10.6	10.7	65.9	335.6
4	7 23	10.7	8.7	8.7	49.4	307.3	Mean...	8 08	11.5	10.4	10.6	68.8	336.1
5	7 06	11.4	9.6	9.7	60.2	316.0	Oct. 13	8 30	10.5	8.9	9.2	35.9	311.5
Oct. 6	7 33	13.7	12.1	12.5	56.9	346.3	13	8 50	10.6	9.1	9.4	38.4	318.6
6	8 20	13.8	12.7	13.1	58.9	335.8	Mean...	8 40	10.6	9.0	9.3	37.2	315.0
Mean...	7 56	13.8	12.4	12.8	57.9	341.0	Oct. 14	8 00	7.8	6.6	6.8	51.1	343.7

* See Coast Survey Report for 1867, Appendix No. 7, p. 136.

1881.	Time. a. m.	Corrected temperature.			Length of	
		Standard.	Bar 1.	Bar 2.	Bar 1.	Bar 2.
	h. m.	° C.	° C.	° C.	μ.	μ.
Oct. 14	8 30	7.9	6.8	7.1	+52.4	+335.4
Mean...	8 15	7.8	6.7	7.0	51.8	339.6
Oct. 15	8 54	7.1	6.3	6.2	55.8	328.1
15	9 38	8.0	7.7	7.8	64.6	355.5
Mean...	9 16	7.6	7.0	7.0	60.2	341.8
Oct. 17	8 20	9.2	8.3	8.5	58.2	329.5
17	8 40	9.3	8.6	8.8	63.9	334.9
Mean...	8 30	9.2	8.4	8.6	61.0	332.2
Oct. 18	8 50	10.2	9.6	8.9	66.0	336.0
18	9 10	10.4	10.1	9.4	79.8	344.0
Mean...	9 00	10.3	9.8	9.2	72.9	340.0
Oct. 19	8 00	12.4	11.0	10.5	56.8	333.2
19	8 25	12.5	11.4	10.9	60.9	339.4
Mean...	8 12	12.4	11.2	10.7	58.8	336.3
Oct. 20	8 00	15.4	12.9	12.7	43.9	325.4
20	8 25	15.4	18.0	12.8	53.6	329.4
Mean...	8 12	15.4	13.0	12.8	48.8	327.4
Oct. 21	8 10	14.6	13.8	13.2	62.4	334.7
21	8 25	14.6	14.0	13.4	67.7	338.5
Mean...	8 18	14.6	13.9	13.3	65.0	336.6
Oct. 22	7 50	11.1	9.4	8.8	66.6	322.9
22	8 10	11.2	9.7	9.1	80.0	340.9
Mean...	8 00	11.2	9.6	9.0	73.3	331.9
Oct. 24	7 15	10.0	7.2	7.2	71.5	334.7
24	7 35	9.9	7.2	7.3	71.4	329.4
Mean...	7 25	10.0	7.2	7.2	71.4	332.0
Oct. 25	7 25	13.2	11.8	11.7	49.3	327.3
25	7 45	13.2	11.9	11.8	57.5	329.8
Mean...	7 35	13.2	11.8	11.8	53.4	328.6
Oct. 26	7 10	14.9	13.7	13.7	52.6	346.8
26	7 30	14.9	13.7	13.7	59.5	347.3
Mean...	7 20	14.9	13.7	13.7	56.0	347.0
*Oct. 27	[1 10]	14.1	14.3	14.2	[82.5]	[355.1]
27	[1 25]	14.3	14.4	14.3	[80.5]	[365.6]
Mean...	[1 18]	14.2	14.4	14.2	[81.5]	[360.4]
Oct. 28	8 00	13.3	12.4	12.3	63.9	338.8
28	8 15	13.3	12.5	12.4	59.1	338.3
Mean...	8 08	13.3	12.4	12.4	61.5	338.6
Oct. 29	7 10	12.2	11.0	11.0	47.1	336.4
29	7 30	12.2	11.0	11.0	52.4	347.1
Mean...	7 20	12.2	11.0	11.0	49.8	341.8
Oct. 31	7 10	10.3	8.4	8.4	41.7	321.4
31	7 25	10.2	8.4	8.3	38.8	323.6
Mean...	7 18	10.2	8.4	8.4	40.2	322.5
Nov. 2	7 20	10.8	8.7	8.7	31.6	325.7
2	7 40	10.6	8.7	8.6	26.7	318.9
Mean...	7 30	10.7	8.7	8.6	+29.2	+322.3
Nov. 3	7 30	7.9	6.1	5.6	35.4	317.9
3	7 50	7.9	6.2	5.7	49.1	328.8
Mean...	7 40	7.9	6.2	5.6	42.2	323.4
Nov. 4	7 50	13.1	12.8	12.4	58.8	333.9
4	8 10	13.2	12.9	12.5	64.9	396.7
Mean...	8 00	13.2	12.8	12.4	61.8	335.3
Nov. 5	8 10	8.1	6.4	6.0	49.2	318.4
Nov. 7	7 55	10.0	8.8	8.5	45.1	316.9
7	8 10	10.0	9.1	8.7	44.1	324.5
Mean...	8 02	10.0	9.0	8.6	44.6	320.7
Nov. 8	7 50	11.1	10.2	10.2	64.0	331.7
8	8 30	11.2	10.4	10.5	57.4	341.1
Mean...	8 10	11.2	10.3	10.4	60.7	336.4
Nov. 11	7 40	7.2	5.0	4.6	47.1	325.5
11	7 55	7.1	5.1	4.8	48.9	340.8
Mean...	7 48	7.2	5.0	4.7	48.0	333.2
Nov. 12	7 35	5.1	3.2	3.1	38.5	327.1
12	7 50	5.0	3.4	3.3	40.5	333.9
Mean...	7 42	5.0	3.3	3.2	39.5	330.5
Nov. 14	8 00	10.7	8.7	8.5	44.6	351.3
14	8 20	10.8	9.1	9.0	52.4	360.9
Mean...	8 10	10.8	8.9	8.8	48.5	356.1
Nov. 16	9 20	6.6	5.5	5.7	51.0	332.0
16	9 40	6.8	5.9	5.9	59.2	345.3
Mean...	9 30	6.7	5.7	5.8	55.1	388.6
Nov. 18	8 50	3.4	2.9	3.1	67.9	347.1
18	9 05	3.5	3.0	3.3	62.2	346.5
Mean...	8 58	3.4	3.0	3.2	65.0	346.8
Nov. 19	8 20	3.7	2.8	2.4	63.8	333.8
19	8 50	3.7	3.2	2.5	54.8	319.3
Mean...	8 35	3.7	3.0	2.5	59.3	326.6
Nov. 21	7 50	3.4	2.0	1.8	56.0	337.2
21	8 10	3.3	2.1	2.0	61.4	347.2
Mean...	8 00	3.4	2.0	1.9	58.7	342.2
Nov. 22	8 10	3.4	2.4	2.2	48.8	323.2
22	8 25	3.5	2.6	2.3	48.7	341.4
Mean...	8 18	3.4	2.5	2.2	48.8	332.3
Nov. 23	7 00	4.8	2.9	2.7	64.7	327.3
23	7 56	4.3	2.8	2.4	58.0	329.3
Mean...	7 28	4.6	2.8	2.6	61.4	328.3
Nov. 24	7 02	3.9	2.3	1.9	62.0	321.1
24	8 02	3.5	2.3	1.6	54.0	336.8
Mean...	7 32	3.7	2.3	1.8	58.0	329.0

* October 27, there were no observations in the morning.

Assuming that the bars were stationary, or nearly so, about the times of comparison, we may deduce the mean error of a comparison of the standard with a base bar from the observed differences of the two corresponding sets of observations.

If

$d =$ this difference, in microns,
$n =$ number of such differences or days,
$e =$ mean error of a comparison or set,
$\varepsilon =$ mean error resulting from *two* sets,

then

$$e = \sqrt{\frac{[dd]}{2n}} \text{ and } \varepsilon = \frac{e}{\sqrt{2}}$$

we find for

base-bar 1 $e = \pm 5.4\ \mu$ and $\varepsilon = \pm 3.8\ \mu$
base-bar 2 $e = \pm 7.4\ \mu$ and $\varepsilon = \pm 5.2\ \mu$

Looking over the table we first notice (Diagram 3, Illustration No. 32) a systematic difference between the temperatures of the standard and of the bars, the former being 1°.47 higher, on the average, while the latter agree within 0°.08. This is entirely due to the fact that the standard was better protected against changes of temperature than the bars, the box containing the former being covered with an additional "steam felting" three-fourths of an inch thick. At or about the maximum temperature of the day the sign of the difference reverses, and the standard is then of lower temperature than the bars.

We next notice, after plotting the tabular results (Diagram 4, Illustration No. 32) that upon the whole the temperature steadily declined between September 18 and November 25 about 15° C., whereas the length of the base-bars remained, and if not exactly the same, at most showed but a trifling *increase* in length. From this, however, we are not to infer that the compensation of the bars was perfect, or nearly so, as will be shown in the discussion of the observations specially made to test the question of the degree of compensation, and which reveals a peculiarity in the behavior of zinc, more fully noticed further on.

DIURNAL VARIATION IN THE LENGTH OF THE BASE-BARS DUE TO THE DIURNAL VARIATION OF THE ATMOSPHERIC TEMPERATURE.

From numerous comparisons made of the base-bars with the standard it became evident that their length was subject to a periodic change depending on the daily temperature variation; but what is of more importance with regard to the length of the base is the fact that this periodic change was, during September, of very small amplitude, and after the middle of October and throughout November it had become permanent and remained apparently constant, but showing a relatively large amplitude. The first period comprises the time of the first measure, the second period that of the second and partial third measure.

In the investigation of the diurnal variation of the length of the base-bars we only need the *form* of the curve representing the variation, so that there is no need of referring the bi-hourly values taken on different days to the same index. The comparisons were not made at the exact even hour, but the results could be grouped and means taken referring nearly to full hours. The corresponding temperatures of the bars are given as read from the *mercurial* thermometers. On September 18 there are hourly observations from $5^h\ 40^m$ a. m. to $5^h\ 40^m$ p. m.; the mean for two adjacent odd hours was combined with the value for the intermediate even hour and set down in the table. On September 16 and 18 the observations do not extend over twenty-four hours, and to eliminate the effect of any change of index or any constant deviation from the average variation on other days (of twelve equidistant comparisons) the mean hourly difference for each of these two days from the corresponding hours on the full days was ascertained and applied as a constant. The same simple process is gone through with for the observed temperatures.

Diurnal variation in the length of the base-bars before the base measure.

Length = 5 meters + tabular quantities in microns.

1881.	Bar.	Midnight.	2^h.	4^h.	6^h.	8^h.	10^h.	Noon.	2^h.	4^h.	6^h.	8^h.	10^h.
Sept. 1	1	57	56	68	39	51	8	−10	0	1	6	16	32
1	2	129	129	155	136	120	82	84	81	106	90	90	95
2	1	32	18	19	44	45	40	40	31	33	36	27	29
2	2	87	68	65	128	135	135	144	140	97	112	112	112
3	1	{34, 35}	34	38	26	15	23	35	23	36	34	48	37
3	2	{108, 118}	108	107	113	112	99	114	112	122	130	123	133
16	1	....	....	....	46	56	60	59	67	52	60	....	....
16	2	....	....	....	312	348	350	344	336	337	331	....	....
18	1	....	....	....	35	44	74	71	67	56	....	....	....
18	2	....	....	....	320	314	327	319	308	289	....	....	....
Mean ...	1	40	36	42	26	30	29	27	26	24	27	30	33
Mean ...	2	110	102	109	117	121	114	117	111	106	110	108	113

This mean diurnal variation in the length of the base-bars in shown graphically by Diagram 5, Illustration No. 32.

***Diurnal variation** in the temperature of the base-bars at the above comparisons before the base measure, by mercurial thermometers with centigrade scale.*

1881.	Bar.	Mid-night.	2^h.	4^h.	6^h.	8^h.	10^h.	Noon.	2^h.	4^h.	6^h.	8^h.	10^h.
		°	°	°	°	°	°	°	°	°	°	°	°
Sept. 1	1	22.5	20.1	17.8	15.9	16.2	19.8	23.4	26.6	28.7	28.5	26.5	23.9
1	2	22.7	20.3	18.2	16.4	15.7	18.3	21.7	25.2	28.1	28.6	26.8	24.2
2	1	21.8	19.6	18.1	16.3	16.6	19.6	22.7	24.9	26.3	26.1	24.1	21.7
2	2	21.9	19.7	18.3	16.4	16.1	18.1	20.9	23.7	25.8	25.9	24.1	21.8
3	1	19.4 18.1	17.1	14.8	13.3	14.0	17.0	19.5	22.3	24.1	24.6	23.3	20.4
3	2	19.5 18.4	17.3	15.1	13.4	13.4	15.5	17.8	20.8	23.4	24.1	23.4	20.9
16	1	......	......	......	17.5	17.1	19.7	24.0	28.2	32.1	33.8	......	......
16	2	......	......	......	17.8	17.7	20.7	24.5	28.2	31.2	32.6	......	......
18	1	......	......	......	15.0	14.4	17.0	20.4	24.2	27.4	......	......	......
15	2	......	......	......	15.6	15.2	17.9	21.0	24.1	26.5	......	......	......
Mean...	1	20.4	18.9	16.9	14.8	14.9	17.8	21.2	24.5	26.9	27.8	24.6	22.0
Mean...	2	20.6	19.1	17.2	15.1	14.8	17.3	20.4	23.6	26.2	27.2	24.8	22.3

The protection of bar 2 is slightly better than that of bar 1. Mean daily range 12°.6.

***Diurnal variation** in the length of the base-bars during the base measure (after the first measure).*

Length = 5 meters + tabular quantities in microns.

1881.	Bar.	Mid-night.	1^h.	^{h}.	3^h.	4^h.	5^h.	6^h.	7^h.	8^h.	9^h.	10^h.	11^h.
Oct. 15	1	......	......	......	......	......	......	......	......	......	55.8	64.6	77.3
15	2	......	......	......	......	......	......	......	......	......	328.1	355.5	367.2
Nov. 22	1	......	......	......	......	......	......	......	......	......	......	......	......
22	2	......	......	......	......	......	......	......	......	......	......	......	......
23	1	48.4	55.8	54.6	61.9	61.0	60.9	64.7	64.7	58.0	80.4	67.1	90.4
23	2	332.2	327.1	330.5	335.2	322.1	321.0	333.5	327.3	329.3	341.3	348.1	353.0
24	1	54.2	67.5	67.7	72.1	57.5	63.6	55.2	62.0	54.0	59.9	71.3	80.6
24	2	326.3	332.7	335.7	338.6	329.5	334.9	333.9	321.1	336.8	334.3	343.9	353.4
Mean...	1	51.3	61.6	61.2	67.0	59.2	62.2	60.0	63.4	56.0	68.6	70.9	86.0
Mean...	2	329.2	329.9	333.1	336.9	325.8	328.0	333.7	324.2	333.0	335.9	350.5	359.2

1881.	Bar.	Noon.	1^h.	2^h.	3^h.	4^h.	5^h.	6^h.	7^h.	8^h.	9^h.	10^h.	11^h.
Oct. 15	1	78.7	80.8	82.9	66.8	62.5	55.7	......	......	......	......	......	......
15	2	361.7	350.6	357.8	352.3	339.4	334.7	......	......	......	......	......	......
Nov. 22	1	......	......	......	......	93.8	80.9	78.8	82.8	65.8	55.8	71.1	63.7
22	2	......	......	......	......	378.3	347.1	329.3	330.4	325.4	323.5	328.4	330.4
23	1	89.1	88.3	84.2	81.9	82.1	66.1	62.8	67.2	61.2	72.1	53.9	58.6
23	2	363.5	365.9	368.5	366.6	353.4	352.6	332.5	332.1	331.7	327.4	323.1	334.7
24	1	74.9	80.3	88.5	80.7	73.1	68.2	69.4	......	......	......	......	......
24	2	360.2	357.9	365.6	362.1	360.9	341.5	347.1	......	......	......	......	......
Mean...	1	84.1	86.3	88.4	79.7	78.9	68.6	68.4	75.0	63.5	64.0	62.5	61.2
Mean...	2	363.1	359.4	365.2	361.7	355.4	345.1	335.4	331.2	328.6	325.4	325.8	332.6

This mean diurnal variation in the length of the bars is shown graphically by Diagram 6, Illustration No. 32.

Diurnal variation in the temperature of the base-bars at the above comparisons, after the first measure of the base, as indicated by mercurial thermometers with centigrade scale.

[The last line contains the corresponding temperature, by mercurial thermometer, of the standard bar.]

1881.	Bar.	Midnight.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
		°	°	°	°	°	°	°	°	°	°	°	°
Oct. 15	1	......	......	......	......	......	......	......	......	......	6.3	7.7	10.2
15	2	......	......	......	......	......	......	......	......	......	6.2	7.8	10.3
Nov. 22	1	......	......	......	......	......	......	......	......	2.5	......	......	......
22	2	......	......	......	......	......	......	......	......	2.2	......	......	......
23	1	8.1	7.2	6.4	5.7	5.0	4.2	3.6	2.9	2.8	3.6	5.2	7.3
23	2	7.9	6.9	6.2	5.4	4.6	3.9	3.3	2.7	2.4	2.8	4.3	6.2
24	1	6.7	5.9	5.2	4.7	4.0	3.3	2.8	2.3	2.3	3.2	4.8	6.9
24	2	6.3	5.5	4.8	4.1	3.6	3.0	2.4	1.9	1.6	2.4	3.9	5.9
Mean ...	1	7.4	6.6	5.8	5.2	4.5	3.8	3.2	2.6	2.5	3.3	4.8	7.0
Mean ...	2	7.1	6.2	5.5	4.8	4.1	3.4	2.8	2.3	2.1	2.6	4.1	6.2
Mean, standard		8.4	7.8	7.2	6.6	6.0	5.4	4.9	4.4	3.9	3.7	4.5	5.8

1881.	Bar.	Noon.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
Oct. 15	1	12.3	14.0	15.7	16.7	16.7	16.4	......	......	......	......	......	......
15	2	12.3	14.0	15.6	16.5	16.6	16.3	......	......	......	......	......	......
Nov. 22	1	......	......	......	......	13.8	13.7	13.1	12.5	11.6	10.7	9.8	8.8
22	2	......	......	......	......	14.4	14.2	13.5	12.6	11.6	10.9	9.6	8.7
23	1	9.1	11.0	12.5	12.9	13.2	12.8	11.9	10.8	9.9	9.1	8.4	7.5
23	2	8.2	10.2	12.2	13.0	13.3	12.7	11.9	10.7	9.8	9.8	8.1	7.2
24	1	9.0	10.3	11.6	12.6	12.8	12.6	12.0	......	......	......	......	......
24	2	8.1	9.7	11.3	12.4	12.8	12.6	11.9	......	......	......	......	......
Mean ...	1	9.0	10.7	12.2	13.0	13.3	13.0	12.2	11.6	10.8	9.9	9.1	8.2
Mean ...	2	8.2	10.0	11.8	12.7	13.2	12.9	12.3	11.6	10.7	9.7	8.9	8.0
Mean, standard		7.3	8.6	9.9	10.8	11.2	11.5	11.0	10.9	10.6	10.1	9.6	9.0

Mean daily range of base-bars 11°.0 C. and of standard 7°.8 C.; the difference is due to the heavier protecting cover of the standard; also the epochs of maximum and minimum are later with the standard than with the base-bars; these relations are shown on Diagram 7, Illustration No. 32.

An examination of the Borda scale readings of the base-bars (mean value) showed that they lagged behind the corresponding (in time) readings of the standard, a fact which is explained by the position of the zinc bar in the base apparatus where it lies *between* two steel bars, and is thus partly protected from changes of temperature; the Borda scale readings of the base-bars are therefore unreliable in consequence of the unequal temperature of the two metals composing the same. No use was made of them.

The observed lengthening of the base-bars with rise of temperature, as shown on Diagram 6, Illustration No. 32, would lead to the inference that the apparatus would be found *shorter* at the close of the base measure than at the beginning in consequence of the gradual *lowering* of the temperature, whereas direct comparisons with the standard showed no such effect (Diagram 4, Illustration No. 32). This behavior can only be explained by a molecular change in the zinc bars producing a shortening, and consequently making the base-bars longer. This is the same phenomenon already noticed in other zinc bars, confirming their liability to take up a new set or a succession of changes.

The length of the base-bars during the measure is determined as follows: For any one day it will depend on the morning comparison of the standard; to this is added differentially the diurnal range for the particular hour taken from the normal range, multiplied by a factor showing the ratio of the range of the temperature on the particular day to the normal range; all ordinates are thus multiplied with this ratio for the whole day. We have seen that before the base measure the normal diurnal range was hardly perceptible (Diagram 5, Illustration No. 32), but during the second and partial third measure it developed into a constant sensible quantity (Diagram 6, Illustration No. 32). The simplest supposition that could be made was to suppose the change from one into

the other took place gradually and uniformly between October 5 and October 15, keeping the small observed daily range up to October 4, on which day the change appears to have commenced (Diagram 4, Illustration No. 32). A table was constructed of normal diurnal range for every day between October 4 and October 15, which thus comprises about one-half of the first measure of the base; after this time the normal diurnal range remained constant. Only that part of the diurnal variation in the length of the apparatus is needed which falls between the hours of 7 a. m. and p. m., and in order to smooth out the curve or to free it from effect of observing error it was expressed by an analytical formula, viz: $L = l + x + yh + zh^2$, where h = number of hours after 7 a. m., and L = resulting length of apparatus (the indices of the bars are not the same for the two epochs, the differential range only being required).

Day before base measure:

$$\text{Base-bar 1,} \quad L_1 = 5\text{m} + \overset{\mu.}{30.5} - \overset{\mu.}{1.18}h + \overset{\mu.}{0.073}h^2$$
$$\text{Base-bar 2,} \quad L_2 = 5\text{m} + 121.2 - 1.85h + 0.060h^2$$

During second and partial third measure:

$$\text{Base-bar 1,} \quad L_1 = 5\text{m} + 57.2 + 7.83h - 0.584h^2$$
$$\text{Base-bar 2,} \quad L_2 = 5\text{m} + 320.8 + 13.23h - 1.051h^2$$

The observed and computed values for daily variation in length of bars are given in the following table; also the hourly differences from the values at 7 a. m., respectively, near which hour the bars are nearly stationary:

Time of day.	Bar 1 before base measure 1.				Bar 1 during base measures 2 and 3.				Change for one day.*
	Observed length.	Computed length.	Δ	Daily range after 7^h.	Observed length.	Computed length.		Daily range after 7^h.	
A. M.	μ.	μ.	μ.	μ.	μ.	μ.	μ.	μ.	μ.
7	28.0	30.5	−2.5	0.0	63.4	57.2	+6.2	0.0	0.0
8	30.0	29.4	+0.6	−1.1	56.0	64.4	−8.4	+ 7.2	+0.7
9	29.6	28.4	+1.2	−2.1	68.6	70.5	−1.9	+13.3	+1.4
10	29.0	27.6	+1.4	−2.9	70.9	75.4	−4.5	+18.2	+1.9
11	27.9	26.9	+1.0	−3.6	86.0	79.2	+6.8	+22.0	+2.3
Noon	26.8	26.4	+0.4	−4.1	84.1	81.8	+2.3	+24.6	+2.6
P. M.									
1	26.2	26.0	+0.2	−4.5	86.3	83.2	+3.1	+26.0	+2.8
2	25.6	25.8	−0.2	−4.7	88.4	83.4	+5.0	+26.2	+2.8
3	24.6	25.7	−1.1	−4.8	79.7	82.5	−2.8	+25.3	+2.7
4	23.5	25.8	−2.3	−4.7	78.9	80.4	−1.5	+23.2	+2.5
5	25.2	26.0	−0.8	−4.5	68.6	77.1	−8.5	+19.9	+2.2
6	26.8	26.4	+0.4	−4.1	68.4	72.7	−4.3	+15.5	+1.8
7	28.6	26.9	+1.7	−3.6	75.0	67.1	+7.9	+ 9.9	+1.2

Time of day.	Bar 2 before base measure 1.				Bar 2 during base measures 2 and 3.				Change for one day.*
	Observed length.	Computed length.	Δ	Daily range after 7^h.	Observed length.	Computed length.	Δ	Daily range after 7^h.	
A. M.	μ.	μ.	μ.	μ.	μ.	μ.	μ.	μ.	μ.
7	119.4	121.2	−1.8	0.0	324.2	320.8	+3.4	0.0	0.0
8	121.3	119.4	+1.9	− 1.8	333.0	333.0	0.0	+12.2	+1.2
9	117.8	117.7	+0.1	− 3.5	335.9	343.1	−7.2	+22.3	+2.4
10	114.4	116.2	−1.8	− 5.0	350.5	351.0	−0.5	+30.2	+3.2
11	115.5	114.8	+0.7	− 6.4	359.2	356.9	+2.3	+36.1	+3.9
Noon	116.6	113.5	+3.1	− 7.7	363.1	360.7	+2.4	+39.9	+4.3
P. M.									
1	113.8	112.3	+1.5	− 8.9	359.4	362.3	−2.9	+41.5	+4.6
2	111.1	111.2	−0.1	−10.0	365.2	361.9	+3.3	+41.1	+4.6
3	108.6	110.2	−1.6	−11.0	361.7	359.4	+2.3	+38.6	+4.5
4	106.0	109.4	−3.4	−11.8	355.4	354.7	+0.7	+33.9	+4.2
5	107.8	108.7	−0.9	−12.5	345.1	348.0	−2.9	+27.2	+3.6
6	109.6	108.1	+1.5	−13.1	335.4	339.2	−3.8	+18.4	+2.9
7	109.0	107.6	+1.4	−13.6	331.2	328.2	+3.0	+ 7.4	+1.9

* Figures in this column are to be used only for days between October 4 and October 14, or for the time of the second half of the first measure.

The method of finding the length of the base-bars is best illustrated by an example. Suppose it is required to find the length of an average bar October 10, between the hours $1^h\ 52^m$ and $2^h\ 22^m$, between which time 22 bars were laid, or 11 with each measuring bar, twenty-two being the usual number united into a mean:

Range of temperature October 10, $27° - 12° = 15°$; normal range, $12°.0$; ratio $= 1.25$.

Normal daily range of length between $7^h\ 38^m$ a. m. and $2^h\ 07^m$ p. m., October 10, for average bar, $14.8 - 2.8 = +12$, and $1.25 \times 12 = +\ 15$

Length of average bar from comparisons at $7^h\ 38^m$ a. m., October 10 .... 5m + 196 μ

Resulting length .... 5m + 211 μ

In this way the whole of the base was computed.

THE MEASURE OF FRACTIONAL LENGTHS OF BASE-BARS.

These occur at the end of the base and at intermediate stones placed in line of fences. In connection with these measures the following results are taken from the office computation:

Length of Brunner centremeter scale $= 10001.0 + 0.178\ (t - 20°\ \text{C.})$ microns.

Value of one turn of micrometer microscopes A and B of Pratt's beam compass comparator $= 83.25\ \mu$ and of one division $= 1.388\ \mu$. No sensible difference between A and B.

Length of nickel-plated brass meter, $= 1\text{m} + 17.76\ \mu\ (t - 3°.50\ \text{C.})$

Length of transfer meters on steel rod, first $= 1\text{m} + 11.2\ \mu\ (t + 9°.78\ \text{C.})$

second $= 1\text{m} + 11.2\ \mu\ (t + 13°.78\ \text{C.})$

third $= 1\text{m} + 11.2\ \mu\ (t + 13°.17\ \text{C.})$

Length of brass meter scale for fractional parts of a meter was found the same as the length of the nickel-plated meter, or $1\text{m} + 17.76\ \mu\ (t - 3°.50\ \text{C.})$

The small ivory scale divided into half millimeters and used in transfers must be taken as sensibly correct.

HEIGHT OF THE YOLO BASE AND REDUCTION TO SEA-LEVEL.

The work of leveling the base-line and connecting the same with a bench-mark at Woodland was executed by Assistant Colonna in August, 1880, with the following results: Ground at Northwest base above ground at Southeast base, by first measure, 81.933 feet; by second measure, in opposite direction, 82.124 feet; mean, 82.028 feet, or 25.002 meters.

Also railroad engineers' bench-mark on California Pacific Railroad at Woodland above ground at Northwest base, from first measure, 94.759 feet; from second measure, in opposite direction, 94.740 feet; mean, 94.750 feet; or 28.880 meters. From levels by the railroad engineers this bench-mark at Woodland is 60.6 feet above mean low water at San Francisco Bay, and from our tidal observations (Coast Survey Report for 1862, page 97) we have the mean rise and fall about $4\frac{1}{2}$ feet; hence bench-mark at Woodland 58.35 feet, or 17.785 meters above the half-tide level of the ocean.

This gives for the height of Northwest base above mean tide-level 46.665 meters, and of Southeast base 21.663 meters.

We have also the average height of the measuring bars above ground 1.25 meters.

If l = length of a base-bar or of any part of the base,

h = its elevation above the half-tide or mean sea level,

ρ = radius of curvature in the direction of the line and for the latitude of its middle point, then the reduction to the sea level

$$\triangle l = l\left(-\frac{h}{\rho} + \frac{h^2}{\rho^2} - \ .\ .\ .\right)$$

And for the whole base

$$\triangle \text{L} = -\Sigma\frac{l\,h}{\rho} + \Sigma\frac{l\,h^2}{\rho^2}\ \ .\ .\ .$$

The second term is inappreciable for the Yolo base. We have from Coast Survey Report for 1876, Appendix No. 18, for $\varphi = 38°36'$ and $\alpha = 16°54'$ $\log \rho = 6.803623$. With these data and

the result of the levels the reduction of the whole line to the sea-level was found to be — 68.055 millimeters, with the separate values for the subdivisions:

Distance from Southeast base.	Average height of bars.	Reduction to sea-level.	Distance from Southeast base.	Average height of bars.	Reduction to sea-level.
	Meters.	*Millimeters.*		*Meters.*	*Millimeters.*
1st kilometer.	21.82	−3.43	12th kilometer.	25.10	−3.95
2d kilometer.	21.28	3.35	13th kilometer.	26.22	4.12
3d kilometer.	21.25	3.34	14th kilometer.	26.98	4.24
4th kilometer.	20.81	3.27	15th kilometer.	28.43	4.47
5th kilometer.	21.41	3.37	16th kilometer.	30.53	4.80
6th kilometer.	21.25	3.34	17th kilometer.	32.20	5.21
7th kilometer.	23.13	3.64	First 400 meters of 18th kilometer.	37.82	2.38
8th kilometer.	22.68	3.57	Last 88 meters of 18th kilometer..	45.24	0.61
9th kilometer.	22.91	3.60			
10th kilometer.	23.01	3.62			Σ = − 68.06
11th kilometer.	23.88	3.75			

TABLE OF RESULTS OF MEASURE.

The following table contains the several results for distance between the kilometer stones, their resulting value, and the final result of the whole base, as computed by Mr. J. G. Porter,* of the computing division. These tabular results are reduced to the sea-level, and with them there are also given the differences from the mean value for each kilometer for the purpose of computing the probable error of the base measure. The second measure was in a direction opposite to that of the first; the third measure was evenly divided in regard to direction:

Kilometers. †	First measure.	Second measure.	Third measure.	Mean.	$\Delta_{,}$	$\Delta_{,,}$	$\Delta_{,,,}$
	Meters.	*Meters.*	*Meters.*	*Meters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*
1	999.93857	999.93674	999.94230	999.93920	+0.63	+2.46	−3.10
2	999.86546	999.86257	999.86442	.86415	−1.31	+1.58	−0.27
3	999.91967	999.92053	....	.92010	+0.43	−0.43	....
4	999.95517	999.95337	....	.95427	−0.90	+0.90	....
5	999.93661	999.93455	....	.93558	−1.03	+1.03	....
6	999.99326	999.99240	....	.99283	−0.43	+0.43	....
7	999.91055	999.91154	....	.91104	+0.49	−0.50	....
8	999.94847	999.95099	....	.94973	+1.26	−1.26	....
9	999.96121	999.96586	....	.96354	+2.33	−2.32	....
10	999.97348	999.97517	....	.97432	+0.84	−0.85	....
11	999.91185	999.90945	....	.91065	−1.20	+1.20	....
12	999.91450	999.91703	....	.91576	+1.26	−1.27	....
13	999.93228	999.93114	999.93243	.93195	−0.33	+0.81	−0.48
14	999.95792	999.95412	999.95857	.95687	−1.05	+2.75	−1.70
15	999.90346	999.89977	999.90253	.90192	−1.54	+2.15	−0.61
16	999.87582	999.87270	999.87359	.87404	−1.78	+1.34	+0.45
17	999.93622	999.93333	999.93454	999.93470	−1.52	+1.37	+0.16
(18)	487.68351	487.67934	487.68100	487.68128	−2.23	+1.94	+0.28
Σ	17486.51801	17486.50060	....	17486.51193	....	....	....

† Counted from Southeast base monument.

It will be noticed that the effect of the introduction of the third partial measure or of the third measure of 8 kilometers was to increase the mean of the first and second measures by only 2.6 millimeters; it is also apparent that the first measure is 17.4 millimeters greater than the second; this may be regarded as accidental, since for some of the intermediate kilometer measures the first one is less than the second. The differences from the respective means are given in the columns headed $\Delta_{,}$, $\Delta_{,,}$, $\Delta_{,,,}$; they keep fairly within a certain reasonable limit, and it is by these that the probable error of the base is computed, *i. e.*, so far as this depends upon the pure measuring error.

* And checked by Mr. A. Ziwet.

These differences do not seem to have any reference to the average temperatures of the bars during the measures, as may be seen from the following table of average temperature for each kilometer:

Kilometer.	First measure.	Second measure.	Third measure.	Mean.	Kilometer.	First measure.	Second measure.	Third. measure.	Mean.
	° C.	° C.	° C.	° C.		° C.	° C.	° C.	° C.
1	23.9	18.3	13.0	18.4	11	21.6	17.0	......	19.3
2	19.8	15.0	11.2	15.3	12	21.0	14.3	......	17.6
3	20.3	17.2	......	18.8	13	21.9	20.2	9.7	17.3
4	24.5	16.5	......	20.5	14	24.1	19.3	6.6	16.7
5	21.7	16.7	......	19.2	15	19.0	21.6	8.7	16.4
6	23.2	15.0	......	19.1	16	17.5	20.0	8.0	15.2
7	24.0	15.9	......	20.0	17	14.1	19.3	15.2	16.2
8	17.8	17.4	......	17.6	18	10.9	17.7	13.2	13.9
9	17.3	15.0	......	16.2	Mean ...	20.1	17.3	......	17.5
10	19.2	14.8	......	17.0					

Excepting the last 4 kilometers the temperature during the second measure was lower than during the first measure, but during the third measure it was considerably lower than during the second; the greatest difference of temperature occurred during the first and third measure of kilometer 14, when it reached 17°.5 C.; yet the results are not sensibly affected thereby, and it may be inferred in general that the value of the coefficient of expansion of the standard as determined at the office at Washington must be fairly correct.

Besides the kilometer stones there were also so-called "fence stones" or subdivisions of the line at the crossing of 9 fences, where they are better protected from the plow than in the open fields. The measures of these stones are given in the following table, computed in the same way as the kilometer stones:

	First measure.	Second measure.	Third measure.	Mean.	Δ′	Δ″	Δ‴
	Meters.	*Meters.*	*Meters.*	*Meters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*
Southeast base–Fence stone.	886.51303	.51165	.51635	886.51368	+0.65	+2.03	−2.67
Fence stone–First kilometer stone.	113.42554	.42509	.42595	113.42552	−0.02	+0.43	−0.43
			1st kilometer .	999.93920			
Second kilometer stone–Fence stone.	206.07160	.07197		206.07178	+0.18	−0.19	....
Fence stone–Third kilometer stone.	793.84807	.84856		793.84832	+0.25	−0.24	....
			3d kilometer ..	999.92010			
Third kilometer stone–Fence stone.	896.67060	.66916		896.66988	−0.72	+0.72	....
Fence stone–Fourth kilometer stone.	103.28457	.28421		103.28439	−0.18	+0.18	....
			4th kilometer .	999.95427			
Sixth kilometer stone–Fence stone.	417.73148	.73403		417.73275	+1.29	−1.28	....
Fence stone–Seventh kilometer stone.	582.17907	.17751		582.17829	−0.78	+0.78	....
			7th kilometer	999.91104			
Seventh kilometer stone–Fence stone.	272.41757	.41790		272.41773	+0.16	−0.17	....
Fence stone–Eighth kilometer stone.	727.53030	.53309		727.53200	+1.10	−1.09	....
			8th kilometer ..	999.94973			
Tenth kilometer stone–Fence stone.	646.53031	.52686		646.52859	−1.72	+1.73	....
Fence stone–Eleventh kilometer stone.	353.38154	.38259		353.38206	+0.52	−0.53	....
			11th kilometer .	999.91065			
Twelfth kilometer stone–Fence stone.	329.82913	.82829	[Corr'n+8.]	329.82879	−0.34	+0.50	....
Fence stone–Thirteenth kilometer stone.	670.10315	.10285	[Corr'n+16.]	670.10316	+0.01	+0.31	....
			13th kilometer .	999.93195			
Fourteenth kilometer stone–Fence stone.	24.13040	.13080	[Corr'n+1.]	24.13061	+0.21	−0.19	....
Fence stone–Fifteenth kilometer stone.	975.77306	.76897	[Corr'n+29.]	975.77131	−1.75	+2.34	....
			15th kilometer .	999.90192			
Fifteenth kilometer stone–Fence stone.	719.26715	.26452	.26274	719.26481	−2.34	+0.29	+2.07
Fence stone–Sixteenth kilometer stone.	280.60867	.60818	.61085	280.60923	+0.56	+1.05	−1.62
			16th kilometer .	999.87404			

Collecting these results, we have the distances of the several fence stones from Southeast base, as follows:

	Meters.
First	886.5137
Second	2 205.8751
Third	3 896.3933
Fourth	6 417.3389
Fifth	7 271.9349
Sixth	10 645.9334
Seventh	12 329.0600
Eighth	14 023.2506
Ninth	15 718.2867

The differences from the mean $\triangle' \; \triangle'' \; \triangle'''$ have been added to show that they are of the same order of magnitude as the former difference $\triangle_, \; \triangle_{,,} \; \triangle_{,,,}$ and would therefore lead to the same probable error of the measure.

DETERMINATION OF THE PROBABLE ERROR OF THE MEASURE OF THE BASE.

The probable error due to the measure proper, which includes contact error, transfer error (end of bar to the ground and back to bar), error in measure of fractional parts of bars, errors in inclination, and in assigned length of the bars, &c., is found by the formula:

$$r_1 = 0.674\sqrt{\left[\frac{\Sigma(\sigma_, - s_,)^2}{n_,(n_, - 1)} + \frac{\Sigma(\sigma_{,,} - s_{,,})^2}{n_{,,}(n_{,,} - 1)} + \; . \; . \; . \; \frac{\Sigma(\sigma_i - s_i)^2}{n_i(n_i - 1)}\right]}$$

Where $s' \; s' \; s'''$ . . . are the several results of n measures of a section of the base and

$$\sigma = \frac{s' + s'' + s''' + \; . \; . \; .}{n}$$

then the probable error r_1 for the whole base of i sections is given by the above expression. We find r_1 from the differences $\triangle_, \; \triangle_{,,} \; \triangle_{,,,}$ which represent the values of $\sigma_i - s_i$

$$r_1 = 0.674\sqrt{22.97} = \pm 3^{mm}.23$$

In case of but two measures* of the base the above formula reduces to $0.337\sqrt{\Sigma\delta^2}$ where $\delta =$ difference in the two measures of a section and n=number of sections.

* We may readily arrange our results into two sets by combining the third measure symmetrically with the first and the second measures, and at the same time preserving the mean as it resulted from the three measures; thus let a, b, c equal the three successive measures of a section, then the combination to form but two values will lead to

$$a_1 = \frac{2a + c}{3} \text{ and } b_1 = \frac{2b + c}{3}.$$

Combining in this way our triple measures we can form the following table of length of kilometers:

Kilometers.	a_1.	b_1.	δ.	Kilometers.	a_1.	b_1.	δ.	Kilometers.	a_1.	b_1.	δ.
	Meters.		*Millimeters.*		*Meters.*		*Millimeters.*		*Meters.*		*Millimeters.*
1	999.9398	.9386	+1.2	8	999.9485	.9510	−2.5	15	999.9032	.9007	+2.5
2	.8651	.8632	+1.9	9	.9612	.9659	−4.7	16	.8751	.8730	+2.1
3	.9197	.9205	−0.8	10	.9735	.9752	−1.7	17	.9357	.9337	+2.0
4	.9552	.9534	+1.8	11	.9118	.9094	+2.4	18	487.6826	.6799	+2.8
5	.9366	.9346	+2.0	12	.9145	.9170	−2.5	Σ	17486.5168	.5071	+9.7
6	.9033	.9924	+0.9	13	.9323	.9315	+0.8	Mean	17486.5119		
7	.9106	.9115	−0.9	14	.9581	.9556	+2.5				

and $r_1 = 0.674\sqrt{\frac{87.18}{4}} = \pm 3^{mm}.15$

With the preceding probable error there needs to be combined the error arising from the transfer of length from the standard to the base-bars. There are 86 comparisons of each bar with the standard and from those taken in pairs we have the means of finding the probable error of a single comparison in the field.

Let d = observed difference between the results of the two corresponding sets as observed in the morning before the measure of the base commenced on that day,

n = number of such differences or days of observation,

D = mean difference, hence $D^2 = \frac{[dd]}{n}$ also $D^2 = 2e^2$ where

e = mean error of an observation or of a set, then

$$e = \sqrt{\frac{[dd]}{2n}}$$

We have from 38 differences for bar$_1$ $\quad e_1 = \sqrt{\frac{2234}{76}} = \pm 5.4\,\mu$

and from the same number of differences for bar$_2$ $\quad e_2 = \sqrt{\frac{4158}{76}} = \pm 7.4\,\mu$

hence the probable error of an average bar $\pm 6.4 \times \frac{2}{3} = \pm 4.3\,\mu$

and for the mean of 172 comparisons $\quad \pm 0.33\,\mu$

hence for the whole base or 3497 average bars $\quad \pm 0.33 \times 3497 = \pm 1^{mm}.16 = r_2$.

In estimating the probable error of the base some allowance should be made for the effect of an uncertainty in the hypothesis adopted with regard to the change from no daily variation to a fixed daily variation in the length of the average bar; our result depends on the assumption that the change from one into the other took place between October 4 and October 14; had we adopted September 18 instead of October 4 the result would have been a systematic greater value of each kilometer in the first measure as compared with the second, and the length of the first measure would have been 17486^m.5499 instead of 17486^m.5180, or 31.9 millimeters greater than the adopted value, the second measure and the third partial measure remaining the same. The probable error would also be raised from $r_1 = \pm 3^{mm}.23$ to $\pm 3^{mm}.68$; the distribution of the daily variation over the greater interval is therefore injurious to the result and was abandoned. Its effect, however, on the whole length would have been an increase of 17486^m.5269 $-$ 17486^m.5119 $= 15^{mm}.0$, and I propose to include one-third of this as an estimate of the uncertainty in question; hence $r_3 = \pm 5^{mm}.0$

We come next to the principal probable error, namely, that arising from the uncertainty in the length of the standard. It has been shown that its uncertainty is $\pm 2.1\,\mu$, the effect on the base is consequently $\pm 2\mu.1 \times 3497$ or $\pm 7^{mm}.344$, which we put $= r_4$. There is also a minute error introduced through the uncertainty in the value of the expansion coefficient $\underset{\pm .21}{57^{\mu}.47}(t - 17^\circ.07)$ The mean temperature of measure of the Yolo base is 17°.5 C., so that the effect of but 0°.4 C. is hardly noticeable; it amounts to $r_5 = \pm 0^{mm}.3$

If we estimate the uncertainty in the leveling and in the height of the half-tide or average level of the sea at $\pm 0^m.35$, we have a probable error in the reduction to the sea-level of $r_6 = \pm 0^{mm}.94$. The error due to imperfect alignment is inappreciable.

Collecting our separate values $r_1\ r_2\ r_3\ r_4\ r_5\ r_6$ we have $r = \sqrt{[rr]} = \pm 9^{mm}.57$

This probable error of the computed length of the base of $\pm 9^{mm}.57$ in 17 486.5119 meters is equivalent to $\pm \frac{1}{1\,827\,200}$ part of the length, or when expressed in a more convenient form it equals $\pm$ 0.547 millimeters per kilometer, or what is the same (notation adopted in Clarke's Geodesy), it equals $\pm 0.55\,\mu$ per meter. The probable error may also be stated as $\pm$ 0.035 inch per English statute mile; the length of the base being 10.8657 statute miles.

The probable error of the measure of the Yolo base, viz, $\pm 0.55\,\mu$ may be compared with similar quantities reached heretofore in our primary base lines; they are given on page 131, Coast Survey Report for 1873, and range from $\pm 2.44\,\mu$ to $1.77\,\mu$ (for the Atlanta or Peach Tree Ridge base, 1872–'73, measured three times).

Addenda C and D contain some remarks on the probable errors of contact or coincidence of lines and of a transfer of bar-end to ground, or of the reverse operation.

FINAL LENGTH OF THE YOLO BASE.

$17486^{m}.51193$ and its logarithm 4.2427031 885
$\pm$ .00957 $\pm$ 2 377

The probable error of the logarithm is checked by $\pm \frac{\triangle l}{l} M$, where $\triangle l$, the probable error (in meters), l the length of the base, and M the modulus for common logarithms.

(A.)—INVESTIGATION OF THE PERMANENCY OF THE INDICATIONS OF BORDA SCALES FORMED OF ZINC AND IRON.

Although the metallic thermometers depending on the differential expansion of zinc and iron, which were used in connection with the Bessel base apparatus, apparently gave satisfactory results, doubts have been raised within a few years past as to the reliability of zinc with respect to permanency of length and of coefficient of expansion after exposure to varying temperatures, artificial or natural. The question being one of importance, it is proposed to give in the following pages an account of the experiences gathered in connection with the new base apparatus. Up to the present time our experience does not extend over more than two years, but it is proposed hereafter to examine at least the standard bars at suitable times, in order that experimental evidence may be had whether or not the bars ultimately attain that permanence of condition which would place their fitness for metallic thermometers beyond doubt.

Borda scales of the five-meter office standard.

We have from direct observations the following corresponding mean values of the mean of the two Borda scales or ½ (A+B), and the mean temperature by corrected mercurial thermometers:

No.	Date.	½ (A+B).	Temp. by ther.
	1881.	*Millimeters.*	° *C.*
1	April 22 to May 2.	7.466	20.42
2	May 4.	7.416	19.17
3	June 15 to 16.	7.616	22.97
4	June 18 to 20.	7.677	24.11
5	June 21.	7.703	24.70
	1882.		
6	February 13 to March 3.	7.268	16.91
7	May 22 to June 10.	7.479	21.40
8	June 20, 22, 26.	7.681	25.83
9	August 25 to September 4.	7.652	24.78
10	September 16 to 26.	7.498	21.81
11	October 14 to 25.	7.316	18.18
12	December 11 to 16.	7.095	13.85
	1883.		
13	January 15 to February 1.	7.023	12.67
14	February 1 to 28.	7.194	16.11

Plotting these values (see accompanying plate, Diagram 1) it became evident that a change took place in the index and expansion between the sixth and seventh series, or between March and May, 1882, at a time when the bar remained on the platform in the comparing room.

Taking means we have for first series $7.^{mm}524$ and $21^{\circ}.38$, now forming the respective differences between each result and the mean and changing signs when needed to make all values +, the sums are $0^{mm}.846$ and $15^{\circ}.28$; hence change of Borda scale for change of 1° C. = $0^{mm}.0554$

Similarly mean for second series, $7^{mm}.367$ and $19^{\circ}.33$; change of scale for 1° C. = $0^{mm}.0510$

With these values we compute the temperatures corresponding to the observed Borda scales, whence the following comparisons in which B indicates temperature derived from Borda scale, and M from mercurial thermometer:

No	B.	M.	M—B.
	°	°	° C.
1	20.33	20.42	+.09
2	19.43	19.17	—.26
3	23.04	22.97	—.07
4	24.14	24.11	—.03
5	24.61	24.70	+.09
6	16.76	16.91	+.15

No.	B.	M.	M—B.
	°	°	° C.
1	21.53	21.40	—.13
2	25.49	25.83	+.34
3	24.92	24.78	—.14
4	21.90	21.81	—.09
5	18.31	18.18	—.13
6	14.00	13.85	—.15
7	12.59	12.67	+.08
8	15.94	16.11	+.17

Since we have proof that the steel bar remained unchanged, there must have occurred a molecular change in the zinc bars about April, 1882. In consequence of these bars taking a new set the index error changed 41 microns, the zinc bars having become *shorter* and the coefficient of expansion *smaller*. Before and after the change the correspondence between the metallic and mercurial thermometers appears satisfactory, as shown in the columns M — B in the above table.

Borda scales of the five-meter field standard.

For this bar we have the following corresponding mean values of the mean of the two Borda scales or $\frac{1}{2}$ (C+D) and the mean temperature by corrected mercurial thermometers.

No.	Date.	$\frac{1}{2}$ (C+D.)	Temp. by ther.	No.	Date.	$\frac{1}{2}$ (C+D).	Temp. by ther.
	1881.	*Millimeters.*	° C.		1881.	*Millimeters.*	° C.
1	April 22 to May 2.	7.516	20.50	15	October 17 to 20.	6.974	10.67
2	June 15, 16, 18 to 20.	7.700	23.60	16	October 20 to 28.	7.088	13.34
3	August 16 to 18.	7.460	19.90	17	October 28 to November 3.	7.016	11.61
4	August 18.	7.918	28.87	18	November 3 to 16.	6.901	9.15
5	August 18 to 23.	7.405	18.62	19	November 16 to 22.	6.635	4.13
6	August 23 to 26.	7.563	22.00	20	November 22 to 23.	6.929	10.29
7	August 26 to 31.	7.536	21.65	21	November 23.	6.719	5.89
8	August 31 to September 2.	7.643	23.54	22	November 23.	6.932	10.38
9	September 2, 3, 4.	7.489	20.60	23	November 23 to 24.	6.704	5.59
10	September 16 to 17.	7.659	24.15	24	November 24.	6.901	9.60
11	September 18 to 19.	7.490	20.93		1883.		
12	September 19 to October 9.	7.271	16.53	25	January 15 to February 1.	7.059	12.69
13	October 4 to 12.	7.161	14.21	26	February 11 to 23.	7.265	16.96
14	October 12 to 17.	6.990	11.18				

The two Diagrams, Nos. 1 and 2 show that the zinc bars were subject to two changes, the first between series 2 and 3, or in July, 1881, when the field standard was transported by railroad to California, a journey of more than 3 000 statute miles.

A second change took place in California after the natural temperature had reached its minimum of about 2° C. on November 21, 1881 (series No. 19 of the table). After this date the bars did not fully recover their length. Taking means as before we have:

First series, mean reading of scales, $7^{mm}.608$; of thermometers, 22°.05 C.; change of scale for 1° C. = .0594

Second series, mean reading of scales, $7^{mm}.306$; of thermometers, 17°.12 C.; change of scale for 1° C. = .0522

Third series, mean reading of scales, $6^{mm}.928$; of thermometers, 10°.20 C.; change of scale for 1° C. = .0485

Table of comparisons of temperature of bar by metallic and mercurial thermometers.

No.	B.	M.	M−B.	No.	B.	M.	M−B.	No.	B.	M.	M−B.	No.	B.	M.	M−B.
	°	°			°	°	° C.		°	°	° C.		°	°	° C.
1	20.50	20.50	....	1	20.07	19.90	−.17	9	20.64	20.93	+.29	1	10.22	10.29	+.07
2	23.60	23.60	...	2	28.84	28.87	+.03	10	16.45	16.53	+.08	2	5.89	5.89	.00
				3	19.02	18.62	−.40	11	14.34	14.21	−.13	3	10.28	10.38	+.10
				4	22.04	22.00	−.04	12	11.07	11.18	+.11	4	5.58	5.59	+.01
				5	21.52	21.65	+.13	13	10.76	10.67	−.09	5	9.64	9.60	−.04
				6	23.57	23.54	−.03	14	12.95	13.34	+.39	6	12.70	12.69	−.01
				7	20.62	20.60	−.02	15	11.57	11.61	+.04	7	17.15	16.96	−.19
				8	23.88	24.15	+.27	16	9.36	9.15	−.21				
								17	4.27	4.13	−.14				

As in the case of the first standard, with each change or shortening, the coefficient of expansion became smaller—the first shortening was 45 microns; the second 24—and it is noteworthy that the bar suffered no change whatever on the return journey from the western to the eastern coast in October, 1882. In general we notice a tolerably fair correspondence between the metallic and mercurial thermometers. The mean error or difference deduced from the above 38 cases* is

$$\sqrt{\frac{\Sigma \triangle^2}{38-4}} = \pm 0^\circ.17 \text{ C}$$

but we must be certain that the condition of the zinc bar remained unchanged. The mercurial thermometers alone were used for the determination of the length of the base-bars.

(B.)—RESULTS OF ROUGH AND PRELIMINARY VALUES FOR LENGTH OF THE YOLO BASE.

In August, 1880, in connection with the spirit-leveling of the line, Assistant Colonna measured the length of the base by means of a 50-meter steel wire under constant strain; this wire he standarded by means of the 4-meter secondary base-bars Nos. 3 and 4, and found for the length 17485.4 meters, a value about 1.1 meters in defect. The error amounts to $\frac{1}{16\,000}$ of the length, nearly.

A second wire measurement was made in September, 1881, by Assistant Gilbert, aided by Sub-assistants Blair and Dickins preparatory to the base measure with the 5-meter bars, by means of which the wire was standarded. The wire was 100 meters in length, and, stretched with a constant force, the measure fell short of the true length of the base 0.6 meters, which is equivalent to $\frac{1}{29\,000}$ of the length, nearly.

The field computation by Mr. Blair and Mr. Gilbert, made during the measure (and after the reduction to the sea-level had been applied), gave the length $17486^{m}.559$, only 47 millimeters in excess

The value used provisionally in the office computations up to this time (May, 1883) for the length of the base was that derived from the Pulgas base, south of San Francisco Bay, as measured by Assistant Cutts in 1853, and brought forward through partly incomplete triangulation to the Yolo base, it was $17486^{m}.86$; it exceeds the true length only $0^{m}.35$ which is equivalent to $\frac{1}{50\,000}$ of the length, nearly. Since all charts and maps in the vicinity of San Francisco and south of it to Monterey, as well as the preliminary computation of the triangulation extending across Nevada to the Utah boundary, depend for their scales and distances on the Pulgas base, it is satisfactory to have the assurance of the reliability of this old base.

(C.)—PROBABLE ERROR OF "MAKING CONTACT" OR OF "COINCIDENCE OF LINES" OF THE CONTACT SLIDES OF THE BASE-BARS.

Observations for the contact error were made at Washington June 15, 16, 1881, for bar 1, and June 18, 20, 1881, for bar 2. In these observations made in the comparing room the bar was left in position, but repeated contact was made with one of the Bessel-Repsold screw-contact level comparators, the contact being made and broken in succession. A hand-glass of low magnifying power was used to establish coincidence of lines.

* On the average each case consists of a mean of 17 separate readings.

Base bar 1: From 120 observations made in 24 sets the sum of the squares of the differences from their respective mean was .02073 turns of micrometer. One turn of micrometer I equals 276.1 μ, and of II, 276.3 μ; hence

$$e_1 = \sqrt{\frac{.455 \times .02073}{120 - 24}} = \pm\, 0.0099 \text{ turns} = \pm\, 2.73\ \mu$$

Base bar 2: From 120 observations made in 24 sets we have

$$e_2 = \sqrt{\frac{.455 \times .02473}{120 - 24}} = \pm\, 0.0108 \text{ turns} = \pm\, 2.98\ \mu$$

These values of e_1 and e_2 include the error of making physical contact and of reading off the Bessel-Repsold comparators. This last probable error was found from 73 observations in 24 sets, for bar 1, equal to $\pm$ .0022 turn or $\pm$ 0.61 μ, and from 73 observations in 24 sets (dates as above), for bar 2, equal $\pm$ .0019 turn or $\pm$ 0.52 μ; hence

Probable error of a coincidence of contact slide for bar 1 $\sqrt{(2.73)^2 - (.61)^2} = \pm\, 2.66\ \mu$.

Probable error of a coincidence of contact slide for bar 2 $\sqrt{(2.98)^2 - (.52)^2} = \pm\, 2.93\ \mu$.

Mean or final value for probable error of "making contact" = $\pm$ 2.80μ.

In the length of a kilometer it amounts to $\pm$ 39.6 microns, and for the whole Yolo base to $2.80\sqrt{3497} = \pm\, 165$ microns—practically a vanishing quantity.

(D.)—PROBABLE ERROR OF A "TRANSFER OF END OF BAR TO GROUND OR OF THE REVERSE OPERATION."

An observation consists of a pointing on the end of the bar and then on the ivory half-millimeter scale on the ground, with the theodolite, say clamp north, and of the same operation with clamp south, in order to eliminate any defect in the horizontality of the axis of the sector or any defect in collimation. The fractional part of a scale subdivision is estimated; the telescope is set equidistant (or nearly so) from bar end and scale, and its focal adjustment answers for both objects. Before each observation the ivory scale is taken off and reset with its 20-division mark over the line in the copper tack or bolt.

On September 8, 1881, in the camp near the middle of the base, 23 observations on four different parts of the scale were made by various observers; from these we find

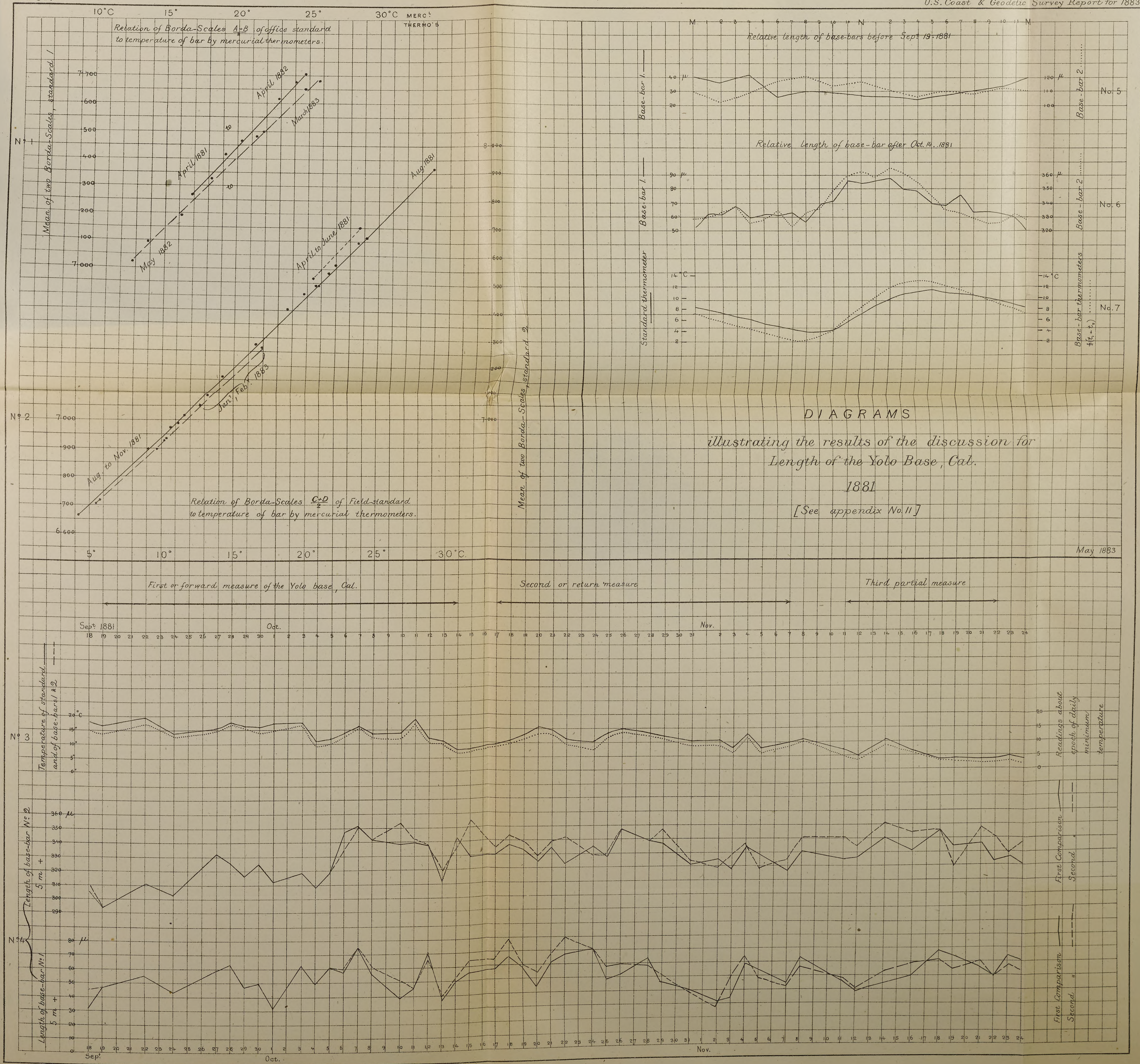
$$e = \pm\, 0.845 \frac{\Sigma \triangle}{n-4} = \pm\, 0^{cm}.010 \text{ or } \pm\, 0^{mm}.10$$

for the probable error of a transfer. The same amount is involved in picking up the ground mark, hence the whole probable error $\pm\, 0^{mm}.14$ Supposing, as for the Yolo base, 18 working days for one measure of the line and that 18 double transfers are involved, the probable error arising would be

$$0.14\ \sqrt{18} = 0^{mm}.60$$

a quantity small enough to be neglected.

In conclusion, I beg leave to add a few remarks relating to any future use of the base apparatus. Notwithstanding the small probable error reached in the measure of the Yolo base, and which I attribute in a great measure to the extreme care taken by the party in charge of the work, the fact brought out of the unexpectedly capricious and otherwise irregular behavior of the zinc bars of the apparatus with respect to heat, renders it doubtful in my mind whether this form of the apparatus would not better be abandoned for either a partly compensating apparatus or a wholly uncompensated one. If we were to replace the zinc bar of the apparatus by a brass bar, we sacrifice 50 per cent. of the compensation, but would probably not be confronted with irregularities which may be troublesome and possibly impracticable to deal with. On the other hand an uncompensated single steel bar put in the place of the present compound bar, if well protected against change of temperature, may lead to results not inferior to those already reached. Whatever may be decided on, I should recommend abandoning the Borda scales and not to neglect taking a comparison with the field standard at the beginning and close of each day's measure.


Relation of Borda-Scales A+B/2 of office standard to temperature of bar by mercurial thermometers.
Mean of two Borda-Scales, standard 1
Relation of Borda-Scales C+D/2 of Field-standard to temperature of bar by mercurial thermometers.
Mean of two Borda-Scales, standard 2
Relative length of base-bars before Sept. 19, 1881
Relative length of base-bar after Oct. 14, 1881
Standard thermometer
Base-bar thermometers
DIAGRAMS
illustrating the results of the discussion for
Length of the Yolo Base, Cal.
1881
[See appendix No. 11]
May 1883
First or forward measure of the Yolo base, Cal.
Second or return measure
Third partial measure
Temperature of standard and of base-bars 1 & 2
Readings about epoch of daily minimum temperature
Length of base-bar No. 2 5 m +
Length of base-bar No. 1 5 m +
First Comparison
Second

ERRATA.

[Appendix No. 12, Coast and Geodetic Survey Report, 1883.]

Page 309. In formula, line 13 from bottom, the ε in the term $n_1\,\varepsilon$ dropped out in the press work.

Page 311. In last column of table, for 2 p. m. the + sign is wanting.

APPENDIX No. 12.

RESULTS OF OBSERVATIONS FOR ATMOSPHERIC REFRACTION ON THE LINE MOUNT DIABLO TO MARTINEZ, CALIFORNIA, IN CONNECTION WITH HYPSOMETRIC MEASURES BY SPIRIT-LEVEL, THE VERTICAL CIRCLE AND THE BAROMETER, MADE IN MARCH AND APRIL, 1880, BY GEORGE DAVIDSON, ASSISTANT.

Reported by CHARLES A. SCHOTT, Assistant.

COAST AND GEODETIC SURVEY OFFICE,
Computing Division, *June* 5, 1884.

INTRODUCTION.

This important series of systematic observations, continued hourly day and night, weather permitting, between March 21 and April 28, 1880, forms the third contribution of materials by Assistant Davidson for the study of the diurnal variation of the atmospheric refraction in connection with comparative hypsometric measures by different instruments and methods. His first observations of this kind were undertaken in March, 1860, at Bodega Head and Ross Mountain, on the coast of California; his second measures were made in September and October, 1879, at Round Top and Jackson Butte, on the western slope of the Sierra Nevada; and the present third series was executed in March and April, 1880, at Mount Diablo and Martinez East, south of Suisun Bay, distant about 50 kilometers (31 statute miles) from the sea-coast. The line passes over the northwestern slope of Mount Diablo, which is steep in the direction toward Martinez. With respect to climate, the region is of a character intermediate between that of the coast and that of the valley of the Sacramento and San Joaquin Rivers, the heat of the valley being here tempered by the inflow of cool air through the Golden Gate. The observers at Martinez East were: G. Davidson, aided by J. J. Gilbert, Assistant; the observers at Mount Diablo were B. A. Colonna, Assistant, aided by J. F. Pratt, Sub-assistant. Martinez East is about 57 meters (or 187 feet), and Mount Diablo about 1173 meters (or 3849 feet) above the average sea-level. To determine the relative position of the stations, a small triangulation was executed in 1880, by Assistant J. J. Gilbert, which depended for its linear measures on the side Goodyear to Island of the triangulation of Suisun Bay in 1864. The resulting geographical positions are as follows:

Mount Diablo △	$\varphi = 37° \ 52' \ 48''.00$	$\lambda = 121° \ 54' \ 49''.07$ west of Greenwich.
Martinez East △	$\varphi = 38 \ \ 01 \ \ 06 \ .13$	$\lambda = 122 \ \ 07 \ \ 38 \ .28$ west of Greenwich.
Azimuth Mount Diablo to Martinez East		129 20 26 .5
Azimuth Martinez East to Mount Diablo		309 12 33 .5

Distance Mount Diablo to Martinez East, 24260^{m}.6 or about 15.1 statute miles.

Between May 10 and May 26, 1880, Assistant B. A. Colonna connected the two stations by lines of spirit-levels, one up, the other down the mountain. The office computation gave the results 3661.618 and 3661.864 feet ± 0.090 feet, hence the mean difference 3661.741 feet or 1116.09 meters ± 0.03 meter. The bench-mark at Martinez East was connected with the tidal bench-mark at the Benicia Arsenal, across the strait, by means of reciprocal and simultaneous vertical angles, measured May 27, 1880, at Martinez East, by J. J. Gilbert, and at the arsenal station by B. A. Colonna. The half-tide level is given by Assistant G. Bradford from six days' continuous tidal observations at Benicia, and checked by reference to a long series of tidal observations recorded at the Mare Is-

land gauge. From these data the Benicia Arsenal bench-mark was found to be 5.83 feet above the half-tide level of the Pacific, and the Martinez bench-mark 181.22 feet above the Benicia mark, hence Martinez East △ above the average sea-level 187.05 feet or 57.01 meters, and Mount Diablo △ above the average sea-level 3848.79 feet or 1173.10 meters. These heights refer to the surface of the ground at the triangulation stations.

In consequence of the large diurnal inequality in the tides and the contracted volume of water in the Strait of Karquinas, I estimate the probable error of the height of the average sea-level not less than ± 0.15 meter.

The weather proved to be abnormally bad while the observations were being made, and the amount of rain which fell in the first twenty-three days of April (10.5 inches or 267 millimeters) is unprecedented, though the observations terminated before the close of the rainy season.

OBSERVATIONS OF DOUBLE ZENITH DISTANCES FOR THE MEASURE OF REFRACTION AND OF DIFFERENCE OF HEIGHT.

For the measure of the reciprocal and simultaneous zenith distances at the two stations, each observer showed when possible heliotrope light, and during the night lantern-light, for fifteen minutes before the full hour, and read the levels of his vertical circle, after which he observed three repetitions of double zenith distance followed by a second set; the levels were then read again, also the barometer, and other meteorological instruments. The two sets of zenith distances occupied from six to seven minutes, and the mean of the two results will nearly give the zenith distance of the opposite station at the full hour.

At Mount Diablo the sun would rise on March 21st, by computation supposing the horizon unobstructed, about $5^h\ 56^m$, and on April 29th about $5^h\ 0^m$; it would set on the first-named day about $6^h\ 19^m$ and on the last day of the series about $6^h\ 55^m$. At the lower station, Martinez East, sunrise would take place about 5^m later and sunset about the same difference earlier than at Mount Diablo.

At *Mount Diablo* the zenith distances were measured with (30-centimeter) vertical circle No. 37, made by Gambey; it is graduated to 5′ and is read by four verniers to 3″ each; value of one division of level = 3″.50. The horizontal axis of the vertical circle, the center of the heliotrope, the center of the lens of the lantern, and the center of the target were 2.04 meters above the top of the copper bolt or Mount Diablo station mark. Consequently all zenith distances (ζ) measured at Mount Diablo have to be diminished by 17″.34, corresponding to a lowering of 2.04 metres; and the total correction to ζ when the Martinez East heliotrope was observed becomes

$$-17''.34 + 11''.91 - 4''.79 = -10''.22$$

and when the lantern was observed

$$-17''.34 + 11''.91 - 5''.86 = -11''.29$$

At *Martinez East* the zenith distances were measured with (25-centimetre) vertical circle No. 80, made by Gambey; it is graduated to 5′ and is read by four verniers to 3″ each; value of one division of level = 3″.84; but it appeared that the observer preferred to give less weight to one* of his six measures, hence the value adopted = 3″.56. A letter received from Assistant Davidson, dated San Francisco, September 3, 1883, gave the following information: Top of pier, 3.485 feet above surface of copper bolt which marks the height of the station; height of center of vertical circle above top of pier 1.110 feet, hence center of vertical circle above spirit-level bench-mark 4.595 feet, or 1.400 meters. We have, also, heliotrope below center of vertical circle $22\frac{3}{16}$ inches = 0.563 meter, corresponding to an angular reduction of —4″.79, and similarly for the lantern 27.13 inches = 0.689 meter, or — 5″.86, and for the day-mark target 20.19 inches = 0.513 metre, or — 4″.36; consequently, all ζ's measured at Martinez East need diminishing by 11″.91 for lowering of 1.40 meters, and the total correction to ζ becomes

$$-11''.91 + 17''.34 = +5''.43$$

The following tables, I and II, contain all resulting zenith distances observed and reduced to the copper bolts or bench-marks at both stations.

* Taken at Mount Lola in 1879.

TABLE I.—*Zenith distances of Martinez East observed at* MOUNT DIABLO *and reduced to station marks at both stations, March and April,* 1880.

$\zeta = 92^\circ\ 43' +$ tabular quantity expressed in seconds.

Hour.	Mar. 21.	Mar. 22.	Mar. 23.	Mar. 26.	Mar. 27.	Mar. 28.	Mar. 29.	Mar. 30.	Mar. 31.	Apr. 6.	Apr. 7.	Apr. 8.	Apr. 9.
A. M.													
1		30.1	24.5		34.8			30.4	14.4			36.3	26.7
2		29.2	26.0		40.3			26.5	14.0			28.1	30.9
3		30.2	22.0					26.6	19.2			29.6	30.9
4		26.9	21.5					26.8	24.1			30.9	35.4
5		26.6	20.4					25.1	[25.7]			32.2	39.6*
6		24.9	24.3	32.7			35.8	27.6					36.3
7		24.6	11.2	31.9			38.8	31.8					
8		26.7	[12.4]	40.0			35.0	30.4					
9		27.7	[14.7]	42.9			36.2	30.4					
10	39.7	30.3		42.7			41.0	34.4				34.7*	
11	34.7	31.9		43.5			36.6	41.6				40.2	39.5*
Noon	38.0	37.1		42.2		47.1*	39.9	42.7				33.7	42.1
P. M.													
1	45.1	43.2	24.6	33.6		44.9	42.0	42.9			40.8	47.0	
2	45.5	45.3	19.7	42.5		45.0	[44.4]	45.9			47.0	46.2	
3	46.6	47.0	10.2	42.6		45.4	44.0	46.8			40.9	48.4	
4	48.0	46.6		42.7		44.4	46.1	47.9			39.6	45.5	
5	46.5	46.6	16.5	42.1			43.0	36.2			32.2	45.6	
6	37.2	38.7					[37.0]	33.2			27.9	37.5	
7	30.4	36.2	18.9	34.5			[35.6]	21.7			28.5	36.1	
8	26.8	34.4	27.1*	33.2			35.2	17.8		20.7*	28.1	38.9	
9	31.0	33.9		33.6			[26.8]	13.8			30.4	34.4	
10	31.3	33.5		28.9			19.3	17.8			34.1	34.3	
11	26.5	29.3		33.2			27.4	20.2			33.3	34.6	
Midn't	26.5	29.0		29.6			32.9	14.4			33.1	32.4	

Hour.	Apr. 10.	Apr. 11.	Apr. 12.	Apr. 13.	Apr. 17.	Apr. 18.	Apr. 19.	Apr. 23.	Apr. 24.	Apr. 25.	Apr. 26.	Apr. 27.	Apr. 28.	Apr. 29.
A. M.														
1		22.1	42.9				26.6		32.1	20.1	28.1	29.2	32.1	23.1
2		20.6	39.2				27.3		35.0	21.6	28.9	24.8	33.6	24.8
3		11.5					31.7		30.3	15.0	22.7	27.1	22.7	[23.8]
4		14.7	37.2				33.9		34.0	10.9	24.9	24.0	17.1	25.4
5		29.3					32 9		28.5	19.0	21.2	25.9	20.2	26.3
6	20.0	33.3				35.9*	31.0		31.4	21.1	[26.2]	26.6	24.0	26.6
7	12.9	28.4	36.3		37.0	39.5	31.7		31.0	[18.8]	28.4	21.8	22.4	27.2
8		25.6	39.9			39.6			35.5	19.4	25.4	28.1	22.5	28.0
9	29.8	33.5				[41.9]			32.3	22.7	27.2	27.9	29.5	31.7
10	35.1	33.5				43.5			33.1	17.3	27.5	30.8	31.5	34.5
11	43.9	37.1	45.1*		42.0	45.5			39.4	32.6	[36.0]	38.1	38.3	37.1
Noon	46.8	47.9	44.9		42.4	46.6		47.0	49.0	30.6	41.7	37.5	37.3	32.1
P. M.														
1	47.1		48.3		44.2	42.9		47.0	50.1	34.1	45.0	36.6	41.1	32.5
2	40.8				44.4	45.2		48.0	50.3	33.3	48.7	46.8	51.4	33.2
3	40.2			46.6*		45.2		47.0	48.6	34.6	47.3	47.2	51.3	29.6
4	37.3			44.8		44.1		47.6	46.6	39.8	43.2	44.2	48.5	26.9
5	39.3			44.0		42.3		46.3	44.2	39.5	40.7	40.9	47.3	22.6
6	31.6					26.3		43.7	36.2	33.2	30.7	36.8	48.4	24.4
7	30.6					31.2		33.1	23.3	28.7	21.8	33.1	41.5	28.1
8	30.9					30.2		34.9	23.3	26.7	25.9	29.6	38.4	25.2
9	33.9	36.0				31.1		38.0	26.8	21.4	21.9	32.0	33.7	
10	32.0	40.7				24.8		34.7	28.2	19.3	29.7	32.2	30.3	
11	12.4	40.3				29.5		32.1	18.6	15.0	38.4	29.4	30.6	
Midn't	20.6	41.2				29.5		31.5	18.8	23.8	26.3	27.5	27.7	

There were also observed April 4, at 9 a. m., 50″.4; at 10 a. m., 53″.2, and April 5, at noon, 47″.3.
Values marked by an asterisk (*) are omitted in the discussion for want of corresponding observations at Martinez East.
Values within rectangular brackets are interpolations explained further on.
The short horizontal bars include periods of 24 hours or multiples thereof.

TABLE II.—*Zenith distances of Mount Diablo, observed at* MARTINEZ EAST *and reduced to station marks at both stations, March and April,* 1880.

$\zeta = 87° 26' +$ tabular quantity expressed in seconds.

Hour.	Mar. 21.	Mar. 22.	Mar. 23.	Mar. 26.	Mar. 27.	Mar. 28.	Mar. 29.	Mar. 30.	Mar. 31.	Apr. 6.	Apr. 7.	Apr. 8.	Apr. 9.
A. M.													
1	....	36.4	34.3	....	54.9	....	....	52.9	59.7	....	....	44.0	39.2
2	....	20.5	29.4	....	58.4	....	....	51.5	59.0	....	....	46.7	83.2
3	....	26.7	24.8	....	....	....	....	49.3	58.2	....	....	49.2	31.3
4	....	21.1	30.1	....	....	....	....	48.4	63.0	....	....	47.6	43.6
5	....	20.2	43.0	....	....	....	....	40.3	(64.2)	....	....	48.2	....
6	....	21.6	47.8	67.2	....	....	[69.1]	51.9	....	....	....	....	39.5
7	....	28.3	40.3	70.4	....	....	71.4	56.4	....	58.2*	....	....	....
8	....	34.6	[46.5]	73.6	....	....	71.6	69.6	....	....	....	....	....
9	....	25.1	[48.9]	75.9	....	....	74.9	69.8	....	56.8*	....	....	....
10	55.3	30.0	....	73.1	....	....	73.2	68.8	....	....	....	....	....
11	64.6	43.1	63.0*	72.3	....	....	70.7	70 1	....	....	....	71.6	....
Noon	68.8	48.6	....	69.1	....	....	76.3	70.7	....	....	....	74.0	52.2
P. M.													
1	70.0	57.2	66.6	72.7	....	77.5	71.5	74.5	....	....	70.9	77.1	....
2	68.8	60 8	68.6	71.6	....	76.0	[72.0]	79.3	....	....	70.6	75.6	....
3	73.9	62.8	65.8	73.1	....	72.8	70.5	77.9	....	....	72.8	75.7	....
4	68.0	63.5	65.6*	72.4	....	73.5	72.7	74.5	....	....	71.6	73.6	....
5	66.3	67.8	62.9	68.9	....	....	73.1	80.2	....	....	67.7	67.5	....
6	57.8	64.7	59.1*	....	....	....	[67.7]	75.1	....	....	62.6	69.6	....
7	50.8	51.6	60.7	61.6	....	....	[67.3]	70.3	....	....	50.1	66.4	....
8	43.8	58.8	....	63.6	....	....	64.2	60.5	....	....	62.0	62.2	....
9	42.6	43.3	....	61.2	....	....	[61.0]	57.4	....	....	53.9	59.8	....
10	30.6	43.3	....	55.8	....	....	59.2	59.0	....	....	48.7	44.8	....
11	25.0	31.2	....	57.1	....	....	60.6	54.4	....	....	48.4	48.5	....
Midn't	32.4	31.3	....	57.5	....	....	59.5	51.9	....	....	48.8	50.6	....

Hour.	Apr. 10.	Apr. 11.	Apr. 12.	Apr. 13.	Apr. 17.	Apr. 18.	Apr. 19.	Apr. 23.	Apr. 24.	Apr. 25.	Apr. 26.	Apr. 27.	Apr. 28.	Apr. 29.
A. M.														
1	....	56.9	65.8	....	....	....	43.3	....	49.7	42.8	51.2	43.5	27.7	26.3
2	....	58.6	63.8	....	....	....	52.8	....	49.9	42.3	49.7	33.5	33.5	27.7
3	....	57.5	....	....	....	....	56.3	....	33.8	42.1	45.8	32.1	26.0	[19.6]
4	....	59.0	65.8	....	....	....	60.1	....	49.9	42.0	52.5	24.8	30.0	16.6
5	....	59.5	....	....	....	....	62.5	....	49.7	44.2	46.2	31.7	26.4	24.1
6	52.6	63.9	65.4*	....	....	....	61.4	....	43.5	47.9	51.2	37.1	30.2	30.5
7	59.1	59.0	66.0	71.7*	74.3	73.7	[56.0]	....	45.7	[48.8]	60.4	39.4	[27.2]	32.5
8	63.8*	65.8	72.8	....	....	74.5	54.4*	....	58.5	58.5	60.7	54.4	28.1	36.9
9	68.4	73.3	....	....	....	[76.8]	....	....	64.5	63.6	60.3	54.1	33.4	36.2
10	73.2	75.2	....	....	....	78.8	....	....	68.7	61.6	65.6	60.4	41.3	28.1
11	76.8	77.8	....	....	76.8	78.1	....	....	69.2	67.4	69.9	62.4	48.7	37.2
Noon	76.2	78.0	72.5	....	78.1	77.2	....	81.6	74.4	68.9	72.8	55.7	60.0	46.6
P. M.														
1	79.6	....	74.8	....	77.5	76.0	....	83.8	77.7	67.4	70.9	53.6	67.4	48.9
2	77.8	....	76.1*	....	78.2	75.6	....	82.8	76.6	69.6	72.8	64.0	73.6	57.8
3	77.5	....	....	....	74.4*	73.1	....	83.5	73.2	67.6	74.7	67.0	73.4	57.3
4	75.0	....	....	73.1	....	74.3	....	83.6	72.7	71.0	70.4	64.8	69.4	56.2
5	76.2	....	....	73.6	....	69.5	....	79.3	79.9	68.5	70.8	60.2	68.6	52.6
6	73.0	....	....	....	....	67.6	....	72.2	75.8	63.4	59.4	50.6	59.4	46.9
7	71.7	....	....	....	....	64.9	....	65.2	68.8	59.3	54.0	46.5	51.6	42.1
8	68.5	....	....	....	....	62.7	....	55.6	45.6	60.5	57.3	41.1	41.2	45.2
9	70.0	65.3	....	....	....	57.9	....	48.1	49.3	49.2	55.1	42.0	39.6	....
10	68.9	65.5	....	....	....	61.2	....	51.2	52.1	50.2	48.8	38.2	39.4	....
11	58.5	65 5	....	....	....	56.8	....	48.3	40.0	51.8	40.4	34.8	46.6	....
Midn't	60.8	64.3	....	....	....	54.4	....	45.5	44.4	49.4	41.1	31.8	35.1	....

Values marked by an asterisk (*) are omitted in the discussion for want of corresponding observations at Mount Diablo.

Values within rectangular brackets are interpolations explainod further on.

The short horizontal bars include periods of twenty-four hours or multiples thereof.

The causes of the larger interruptions of the observations were the following: March 24 to 26, Mount Diablo capped by clouds, rain, and snow-storms; April 1 to 6, stormy weather, Mount Diablo in clouds; April 14 to 17, heavy rain storms; April 20 to 23, rain and snow storms.

COMBINATION OF THE PRECEDING TABULAR ZENITH DISTANCES TO OBTAIN A HOMOGENEOUS SERIES OF HOURLY MEAN VALUES.

Before the tabular results could be conveniently submitted to combination and discussion, which in consequence of the breaks and irregular distribution of the observations would be a laborious task, they required to be molded into a systematic series of hourly values. Such a series must exhibit the diurnal variation in ζ and in the angle of refraction as smoothly as the broken record will admit; the process, however, must involve nothing arbitrary, and must apply alike to the two stations. Were there no interruptions, the simple hourly means during the whole time of occupation would give the series; we therefore first select the number of days of twenty-four consecutive (hourly) observations, irrespective of the hour of beginning; of such there are twelve, provided we first supply by interpolation a few gaps of one hour each, and in two cases of two consecutive hours. These interpolated values are indicated in the preceding tables, and the beginning and ending of each twenty-four hour period is shown by short horizontal bars. For interpolation of an intermediate hour comparison is made with the preceding, and, if practicable, also with the following hour throughout the series and the mean result is set down; thus to illustrate the principle let it be required to find ζ for 8 a. m., March 23, at Mount Diablo: We have the mean difference for the hours 7 and 8 from twelve days equal $+1''.2$, hence interpolated value $11''.2+1''.2=12''.4$; similarly mean difference for hours 8 and 9 from eleven days equal $+2''.3$, hence interpolated value for 9 a. m., $14''.7$. This series from twelve complete days is called the mean series, and the next step is to join to it all broken series, in order that every observation may be represented in the final values. This is readily done by referring all observations (not yet used) on any day to "the mean series," by comparing the respective means for homologous hours and applying the difference of these means as a constant to every observation on that day; thus for March 23, the mean of the fourteen observed values (inclusive of the two in brackets) at Mount Diablo is $19''.1$, the mean for the *same hours* in the mean series is $31''.6$, hence correction to each of the 5 values on March 23, between 1 and 7 p. m., equals $+12''.5$. The referred values so obtained were tabulated and the sums and means were taken for each hour throughout the record, and consequently include the unchanged values belonging to the twelve complete days. Tables III and IV contain the mean series, the number n of days of observation at each hour, and the resulting homogeneous series for the two stations.

TABLE III.—*Observations at Mount Diablo, California, March and April*, 1880.

Resulting hourly series of zenith distances ζ' of Martinez East, $92^\circ\ 43'+$ tabular seconds.

Hour.	12-day mean series.	n.	n day resulting series.	Hour.	12-day mean series.	n.	n day resulting series.
A. M.	″		″	P. M.	″		″
1	26.1	16	26.3	1	43.1	20	41.5
2	26.0	16	26.2	2	45.5	19	43.7
3	23.6	14	23.8	3	45.5	18	43.0
4	23.7	15	24.5	4	45.0	18	43.4
5	25.1	13	25.3	5	42.7	18	40.3
6	27.7	15	27.7	6	36.1	15	35.0
7	26.3	17	26.8	7	30.6	17	30.8
8	27.4	14	28.2	8	29.5	16	29.8
9	29.3	14	30.2	9	28.3	16	29.0
10	33.2	14	33.5	10	27.8	16	28.8
11	38.0	16	37.8	11	25.8	16	27.6
Noon	41.2	19	39.7	Midn't	25.7	16	27.2

TABLE IV.—*Observations at Martinez East, California.*

Resulting hourly series of zenith distances ζ of Mount Diablo, 87° 26′ + tabular seconds.

Hour.	12-day mean series.	n.	n day resulting series.	Hour.	12-day mean series.	n.	n day resulting series.
A. M.	″		″	P. M.	″		″
1	43.7	16	43.9	1	70.8	20	69.9
2	42.4	16	42.8	2	72.8	19	72.1
3	39.4	14	39.7	3	73.0	18	72.4
4	41.5	15	42.8	4	71.6	18	71.2
5	42.7	13	42.8	5	71.7	18	70.3
6	40.3	15	46.9	6	65.6	15	65.4
7	47.1	17	50.1	7	60.2	17	59.8
8	54.6	14	55.5	8	55.0	16	56.2
9	56.3	14	57.2	9	51.3	16	51.7
10	58.7	14	59.2	10	50.2	16	49.8
11	63.2	16	63.5	11	45.7	16	46.2
Noon	69.3	19	66.9	Midn't	44.8	16	46.8

Diurnal variation in the angle of refraction.—In order to exhibit the angle of refraction at any hour we need to know the true zenith distances at each station of the other; these we find by means of the expressions:

$$\tfrac{1}{2}(z' + z) = 90^\circ + \frac{s}{2\,\rho \sin 1''} \qquad \tfrac{1}{2}(z' - z) = \tan^{-1}\left\{\frac{h' - h}{s}\left(1 - \frac{h' + h}{2\rho} - \frac{s^2}{12\rho^2}\right)\right\}$$

where $z\ z'$ = the true zenith distances in case of no refraction,

$h\ h'$ = the heights above sea-level, of the lower and upper stations or $h = 57^m.01$ and $h' = 1173^m.10$

s = linear distance at the sea-level between the two stations, $\log s = 4.3849011$

ρ = radius of curvature to the earth's surface for the middle latitude of the stations and for the azimuth of the line of junction.

We have for Clarke's spheroid with $\varphi = 37^\circ\ 57'$ and $\alpha = 129^\circ\ 16'$

$$\log \rho = 6.804518$$

hence with h and h' as given by the spirit-level

$$z' = 92^\circ\ 44'\ 33''.89 = \text{true zenith distance at Mount Diablo,}$$
$$z = 87\ \ 28\ \ 30\ \ .99 = \text{true zenith distance at Martinez East;}$$

hence the angles of refraction $\triangle z'$ and $\triangle z$ or the difference of the true and apparent zenith distances, become

$$\triangle z' = z' - \zeta' \text{ at Mount Diablo,}$$
$$\triangle z = z - \zeta \text{ at Martinez East.}$$

The numerical values are given in Table V.

Diurnal variation in the coefficient of refraction.—For the computation of the coefficient of refraction m we have the simple expressions for the upper and lower station:

$$m' = \frac{\triangle z'}{\psi} \text{ and } m = \frac{\triangle z}{\psi}$$

and for the mean coefficient

$$m_0 = 0.5 - \frac{\zeta + \zeta' - 180}{2\,\psi}$$

where ψ = horizontal distance expressed in angular value or

$$\psi = \frac{s}{\rho \sin 1''} = 784''.89$$

The numerical values of m', m, m_0 are given in Table V.

Resulting difference of height of the two stations depending on the measured zenith distances and diurnal variation of error of computed height.—The difference of height deducible from zenith distances is given by

$$\triangle h = h' - h = s \tan \tfrac{1}{2}(\zeta' - \zeta) \left[1 + \frac{h+h'}{2\rho} + \frac{s^2}{12\rho^2} \right]$$

the numerical value of which is given for each hour in Table V.

TABLE V.—*Diurnal variations in the angle of refraction, in the coefficient of refraction and in error of computed difference of height.*

Hour.	Angle of refraction. At Mt. D. $\triangle z'$.	Angle of refraction. At M. E. $\triangle z$.	Difference in angle $\triangle z - \triangle z'$.	Coefficient of refraction. For Mt. D. m'	Coefficient of refraction. For M. E. m	Coefficient of refraction. Mean m_0	$\triangle h$	$\triangle h$ —1116.09
A. M.	"	"	"				*Meters.*	*Meters.*
1	67.6	107.1	39.5	.0861	.1364	.1113	1118.42	2.33
2	67.7	108.2	40.5	863	.1378	.1120	8.48	2.39
3	*70.1	*111.3	*41.2	*893	*.1418	*.1155	8.51	*2.42
4	69.4	108.2	38.8	884	.1378	.1131	8.37	2.28
5	68.6	108.2	39.6	874	.1378	.1126	8.42	2.33
6	66.2	104.1	37.9	843	.1326	.1085	8.33	2.24
7	67.1	100.9	33.8	855	.1286	.1071	8.09	2.00
8	65.7	95.5	29.8	837	.1217	.1027	7.85	1.76
9	63.7	93.8	30.1	812	.1195	.1003	7.87	1.78
10	60.4	91.8	31.4	770	.1170	.0970	7.95	1.86
11	56.1	87.5	31.4	715	.1115	.0915	7.95	1.86
Noon	54.2	84.1	29.9	691	.1072	.0881	7.85	1.76
P. M.								
1	52.4	81.1	28.7	668	.1033	.0850	7.78	1.69
2	†50.2	78.9	28.7	†640	.1005	†.0822	7.78	1.69
3	50.9	†78.6	27.7	649	†.1001	.0825	7.72	1.63
4	50.5	79.8	29.3	643	.1017	.0830	7.83	1.74
5	53.6	80.7	27.1	683	.1028	.0855	7.69	1.60
6	58.9	85.6	†26.7	750	.1091	.0920	7.67	†1.58
7	63.1	91.2	28.1	804	.1162	.0983	7.75	1.66
8	64.1	94.8	30.7	817	.1208	.1012	7.90	1.81
9	64.9	99.3	34.4	827	.1265	.1046	8.12	2.03
10	65.1	101.7	36.6	829	.1296	.1063	8.25	2.16
11	66.3	104.8	38.5	845	.1335	.1090	8.36	2.27
Midn't	66.7	104.7	38.0	.0850	.1334	.1092	8.33	2.24
			Mean	.0788	.1211	.1000	1118.05	1.96

In the above table an asterisk (*) indicates a maximum and a dagger (†) a minimum value.

From the contents of this table we arrive at the following conclusions: First, in regard to the *angle of refraction.* This angle, for all hours of day and night, is larger at the lower station than at the upper station, which is in conformity with the increased density of the air at the lower station. The difference is a maximum at 3 o'clock a. m., or at a time preceding the coldest part of the day by one or two hours, and the difference is a minimum at 6 o'clock p. m., apparently following the warmest part of the day by three or four hours. The diurnal range of the angle of refraction is less at the upper station (19″.9) than at the lower station (32″.7). The same laws necessarily hold with respect to the coefficient of refraction, *i. e.*, at the lower station we have the greater coefficient and greater daily range; at the upper station the smaller amount and less variation. Maximum value of coefficient about 3 a. m., and minimum value about 2:30 p. m., closely approximating to the epochs of the diurnal extremes of temperature. At Bodega Head and Ross Mountain, California,* the refraction was a minimum as early as 10 a. m., and for the greater number of hours during daylight the angle of refraction was larger at the upper station than at the lower one—facts which we now recognize as local and temporary anomalies. At Ragged

* Coast Survey Report for 1876, Appendix No. 16.

Mountain,* Maine, the refraction was near a minimum throughout the hours 10 a. m. to 3 p. m., and the observations (as yet unpublished) at Round Top and Jackson Butte, California, give a minimum refraction at 2:30 p. m. With respect to the computed difference of height, we find it too great, as compared with the true difference given by the spirit-level for all hours of the day and night, but less in excess during the day (1.58 m. at 6 p. m.) and more during the night hours (2.42 m. at 3 a. m.). This may be traced to the erroneous assumptions, involved in the formula, of equal angles of refraction at the stations, and of considering the line of sight as part of an arc of a circle instead of assigning to it a shorter radius of curvature toward the lower station, where it is more bent than at the opposite end. The hourly excess of computed over true height follows the same law as the hourly excess of the angle of refraction at the lower over that of the upper station.

The leading numbers of Table V are shown graphically on accompanying plate.

For further discussion of our data, we need the meteorological observations made in connection with the zenith distances; these are contained in the following pages:

Meteorological record at Mount Diablo, March and April, 1880.—The barometer used was Green, No. 1357; its cistern was in the same horizontal plane as the copper bolt marking the station. On several occasions the instrument had to be taken for safety to a shelter 4½ feet below the mark, for which the corresponding correction is —.004 inch. Index correction from March 21 to March 23, inclusive, —.003 inch. During the stormy days of the 24th and 25th moisture got into the cistern, and, after cleaning the instrument on the 26th, the index correction was found to be +.092 inch, depending on comparisons made at San Francisco after the return of the party. There is no reference to any correction to readings of attached thermometer. The two thermometers, Nos. 447 and 448, are said to have no index correction; one of these was used for dry, the other for wet bulb. There was also a boiling point apparatus, C. S. No. 3, placed 2 meters below the station mark. All the meteorological instruments were hung in a wooden box, with sides of lattice work, roofed in, and large enough for an observer to crawl in from underneath. The bulbs of the thermometers were exposed to the surface radiation within the open structure The wind and state of the atmosphere were noted.

Meteorological record at Martinez East, March and April, 1880.—The barometer used was Green No. 2017 (of Smithsonian pattern); when taken from San Francisco it had an index correction of +0.063 inch as compared with the Signal Service barometer. Its cistern was 24¾ inches, or 0.629 meter below the axis of the vertical circle, hence 0.77 meter above station mark, and its reduction is +.003 inch. There is no information respecting index corrections to any of the thermometers at this place. The wet and dry bulb thermometers, by J. Green, were placed in the north-northwest side of the observatory and protected as far as practicable from the effects of radiation. They were read from the inside through a pane of glass, which, in case of little or no wind, was moved aside to permit circulation of air. The boiling-water thermometer, No. 16017, by J. Green, was placed in the north-northwest corner of the observatory, with its bulb 26½ inches below the axis of the vertical circle. A solar radiation thermometer was placed in a box south of the observatory and 2½ feet above ground; a minimum thermometer was on the north side of the building, 6 inches above the surface of the ground.

Tables VI and VII contain the results of all observations made for atmospheric pressure; Tables VIII and IX the results of all observations made for atmospheric temperature, and Tables X and XI the record for atmospheric moisture.

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* Coast Survey Report for 1876, Appendix No. 17.

TABLE VI.—*Atmospheric pressure observed at Mount Diablo, March and April,* 1880.

Mercurial column reduced to temperature 0° C.; corrections for index error and reduction to station mark are applied. The observations were generally taken about ten minutes after the full hour. The short horizontal bars indicate the same periods of twenty-four hours or multiples thereof as explained in correction with the observations of the zenith distances. Values in parenthesis are interpolated.

25 inches + tabular quantity.

Hour.	Mar. 21.	Mar. 22.	Mar. 23.	Mar. 26.	Mar. 27.	Mar. 28.	Mar. 29.	Mar. 30.	Mar. 31.	Apr. 6.	Apr. 7.	Apr. 8.	Apr. 9.
A. M.													
1	....	1.200	1.034	....	1.278	....	....	1.215	1.214	....	....	1.257	1.235
2	....	1.197	1.016	....	1.263	....	....	1.211	1.221	....	....	1.256	1.239
3	....	1.190	1.009	....	....	....	....	1.209	1.201	....	....	1.267	1.231
4	....	1.184	1.000	....	....	....	....	1.204	1.201	....	....	1.269	1.219
5	....	1.182	1.006	....	....	....	....	1.209	(1.202)	....	....	1.272	1.207
6	....	1.179	1.007	....	....	....	1.198	1.219	....	....	....	....	1.195
7	....	1.175	1.006	....	....	....	1.211	1.233	....	....	....	....	....
8	....	1.188	(1.012)	....	....	....	1.217	1.249	....	....	....	....	....
9	....	1.184	(0.998)	....	....	....	1.220	1.257	....	....	....	....	....
10	1.298	1.191	....	....	....	....	1.225	1.279	....	....	....	1.293	....
11	1.288	1.184	....	....	....	....	1.225	1.276	....	....	....	1.284	1.175
Noon	1.288	1.175	....	....	....	1.113	1.225	1.279	....	....	....	1.291	1.166
P. M.													
1	1.262	1.148	0.984	....	....	1.079	1.212	1.269	....	....	1.264	1.278	....
2	1.247	1.129	0.966	....	....	1.102	1.209	1.261	....	....	1.246	1.265	....
3	1.236	1.120	0.965	....	....	1.090	1.232	1.257	....	....	1.231	1.247	....
4	1.244	1.101	0.945	....	....	1.083	1.210	1.262	....	....	1.228	1.236	....
5	1.235	1.087	0.927	....	....	1.084	1.207	1.255	....	....	1.233	1.231	....
6	1.230	1.092	0.912	....	....	....	1.211	1.246	....	....	1.236	1.233	....
7	1.225	1.079	0.912	1.324	....	....	(1.212)	1.234	....	....	1.245	1.230	....
8	1.228	1.076	0.916	1.317	....	....	1.213	1.232	....	1.292	1.253	1.240	....
9	1.229	1.069	....	1.321	....	....	1.217	1.225	....	....	1.264	1.244	....
10	1.224	1.067	....	1.317	....	....	1.210	1.225	....	....	1.267	1.245	....
11	1.218	1.060	....	1.309	....	....	1.209	1.224	....	....	1.263	1.247	....
Midn't	1.213	1.043	....	1.300	....	....	1.212	1.220	....	....	1.262	1.243	....

Hour.	Apr. 10.	Apr. 11.	Apr. 12.	Apr. 13.	Apr. 17.	Apr. 18.	Apr. 19.	Apr. 23.	Apr. 24.	Apr. 25.	Apr. 26.	Apr. 27.	Apr. 28.	Apr. 29.
A. M.														
1	....	1.246	1.130	....	....	....	1.178	....	1.246	1.191	1.196	1.176	1.129	1.149
2	....	1.243	1.120	....	....	....	1.172	....	1.241	1.177	1.193	1.163	1.124	1.136
3	....	1.248	....	....	....	....	1.184	....	1.232	1.174	1.182	1.159	1.130	(1.150)
4	....	1.255	1.136	....	....	....	1.744	....	1.229	1.170	1.179	1.153	1.133	1.140
5	....	1.256	....	....	....	....	1.164	....	1.225	1.172	1.188	1.146	1.131	1.128
6	1.201	1.264	....	....	....	1.113	1.170	....	1.238	1.176	(1.204)	1.158	1.138	1.141
7	1.216	1.268	1.116	....	0.937	1.123	1.158	....	1.249	(1.183)	1.211	1.157	1.147	1.154
8	....	1.267	1.111	....	....	1.144	....	....	1.263	1.200	1.216	1.158	1.150	1.164
9	1.239	1.270	....	....	....	(1.171)	....	....	1.264	1.200	1.216	1.170	1.166	1.177
10	1.263	1.265	....	....	....	1.194	....	....	1.276	1.211	1.229	1.174	1.174	1.181
11	1.258	1.267	1.129	....	1.014	1.205	....	....	1.276	1.215	(1.227)	1.176	1.177	1.193
Noon	1.257	1.258	1.103	....	1.013	1.213	....	1.275	1.270	1.212	1.225	1.177	1.172	1.203
P. M.														
1	1.245	....	1.079	....	1.001	1.214	....	1.262	1.269	1.214	1.228	1.177	1.174	1.191
2	1.242	....	....	....	1.010	1.218	....	1.263	1.262	1.209	1.226	1.169	1.166	1.186
3	1.230	....	....	1.149	....	1.222	....	1.268	1.244	1.200	1.213	1.159	1.157	1.183
4	1.233	....	....	1.147	....	1.219	....	1.265	1.235	1.200	1.207	1.159	1.149	1.181
5	1.228	....	....	1.126	....	1.210	....	1.262	1.225	1.192	1.199	1.148	1.136	1.170
6	1.225	....	....	....	....	1.209	....	1.263	1.219	1.182	1.192	1.137	1.138	1.171
7	1.224	....	....	....	....	1.216	....	1.282	1.223	1.185	1.197	1.141	1.152	1.169
8	1.235	....	....	....	....	1.228	....	1.287	1.227	1.198	1.199	1.154	1.162	1.185
9	1.239	1.161	....	....	....	1.228	....	1.292	1.225	1.204	1.215	1.157	1.168	....
10	1.237	1.150	....	....	....	1.211	....	1.278	1.220	1.206	1.198	1.147	1.166	....
11	1.244	1.145	....	....	....	1.206	....	1.278	1.213	1.204	1.193	1.148	1.174	....
Midn't	1.252	1.135	....	....	....	1.188	....	1.267	1.206	1.203	1.188	1.147	1.167	....

The following additional observations were made: April 4, 9 a. m., 1.222; 10 a. m., 1.229 and April 5, noon, 1.157.

TABLE VII.—*Atmospheric pressure observed at Martinez East, March and April,* 1880.

Mercurial column reduced to temperature 0°; corrections for index error and reduction to station mark are applied. The observations were made on the average about five minutes past the full hour. Some observations taken on March 24 and March 25 are not tabulated for want of corresponding observations at Mount Diablo. Values in parenthesis are interpolated.

29 inches + tabular quantity.

Hour.	Mar. 21.	Mar. 22.	Mar. 23.	Mar. 26.	Mar. 27.	Mar. 28.	Mar. 29.	Mar. 30.	Mar. 31.	Apr. 6.	Apr. 7.	Apr. 8.	Apr. 9.
A. M.													
1	....	0.980	0.793	....	1.085	....	....	1.056	1.027	....	....	0.923	0.895
2	....	0.968	0.778	....	1.069	....	....	1.052	1.011	....	....	0.925	0.888
3	....	0.955	0.779	....	1.051	....	....	1.045	1.005	....	....	0.922	0.875
4	....	0.957	0.780	....	1.022	....	....	1.050	0.979	....	....	0.921	0.875
5	....	0.962	0.802	....	....	....	....	1.065	0.980	....	....	0.921	0.863
6	1.093	0.973	0.811	1.091	....	....	(1.029)	1.086	0.994	....	....	0.964	0.857
7	....	0.959	0.820	1.096	....	....	1.042	1.098	0.992	....	....	....	0.898
8	....	0.961	0.827	1.111	....	....	1.053	1.110	0.991	....	....	....	0.891
9	1.119	0.975	0.814	1.180	....	....	1.067	1.110	....	....	....	0.952	0.875
10	1.107	0.978	0.834	1.171	....	....	1.068	1.113	....	....	....	0.987	0.842
11	1.098	0.950	0.821	1.176	....	....	1.059	1.103	....	....	1.016	0.965	0.848
Noon	1.089	0.912	0.810	1.188	....	....	1.057	1.096	....	....	0.992	0.947	0.822
P. M.													
1	1.055	0.892	0.804	1.182	....	0.887	1.055	1.085	....	....	0.976	0.985	....
2	1.029	0.852	0.802	1.156	....	0.862	1.046	1.071	....	....	0.948	0.895	....
3	1.006	0.832	0.787	1.136	....	0.864	1.026	1.053	....	....	0.920	0.880	....
4	0.986	0.821	0.785	1.131	....	0.891	1.014	1.050	....	....	0.903	0.876	....
5	0.995	0.793	0.777	1.143	....	0.891	1.027	1.057	....	....	0.908	0.858	....
6	1.002	0.807	0.756	1.137	....	0.907	1.038	1.064	....	....	0.922	0.863	....
7	0.976	0.802	0.769	1.130	....	....	(1.042)	1.062	....	1.035	0.922	0.832	....
8	0.991	0.811	0.759	1.122	....	0.898	1.045	1.039	....	1.039	0.918	0.842	....
9	1.004	0.826	0.759	1.138	....	0.899	1.055	1.050	....	1.041	0.926	0.868	....
10	0.989	0.824	0.757	1.123	....	0.928	1.048	1.047	....	1.049	0.939	0.873	....
11	0.988	0.819	0.737	1.109	....	....	1.065	1.039	....	....	0.942	0.907	....
Midn't	0.979	0.805	0.739	1.095	....	....	1.048	1.032	....	....	0.944	0.910	....

Hour.	Apr. 10.	Apr. 11.	Apr. 12.	Apr. 13.	Apr. 17.	Apr. 18.	Apr. 19.	Apr. 23.	Apr. 24.	Apr. 25.	Apr. 26.	Apr. 27.	Apr. 28.	Apr. 29.
A. M.														
1	....	1.016	0.912	0.807	....	....	0.991	....	1.010	0.922	0.943	0.882	0.785	0.772
2	....	0.999	0.913	0.805	....	....	0.986	....	1.019	0.904	0.954	0.852	0.781	0.768
3	....	1.010	0.885	0.823	....	....	1.000	....	1.015	0.895	0.931	0.851	0.791	0.783
4	....	1.000	0.876	0.819	....	....	0.957	....	1.004	0.917	0.944	0.853	0.793	0.761
5	....	1.012	0.875	0.849	....	....	0.964	....	1.006	0.929	0.949	0.857	0.790	(0.760)
6	0.972	1.023	0.879	0.858	....	0.968	0.971	1.038	1.017	0.934	0.966	0.882	0.880	0.786
7	0.978	1.030	0.893	0.890	0.750	0.959	(0.959)	1.062	1.020	0.925	0.962	0.882	0.825	0.800
8	0.997	1.017	0.870	0.893	0.766	0.964	0.970	1.041	1.020	0.946	0.954	0.879	0.821	(0.804)
9	0.972	1.022	0.874	0.932	....	0.991	....	1.076	1.039	0.976	0.962	0.877	0.814	0.808
10	1.016	1.022	0.837	0.938	....	1.014	....	1.074	1.019	0.959	0.978	0.846	0.818	0.808
11	(1.010)	1.011	0.861	0.937	0.798	1.011	....	1.078	1.036	0.955	0.962	0.838	0.813	0.804
Noon	1.009	0.988	0.817	0.934	0.773	1.005	....	1.066	0.988	0.953	0.936	0.821	0.791	0.795
P. M.														
1	(1.004)	0.968	0.799	0.935	0.807	1.027	....	1.046	0.994	0.937	0.919	0.826	0.776	0.795
2	1.002	0.935	0.795	0.957	0.796	1.007	....	1.035	0.967	0.905	0.908	0.824	0.762	0.785
3	0.984	0.939	0.791	0.957	0.789	1.021	....	1.032	0.947	0.907	0.898	0.785	0.737	0.772
4	0.981	0.936	0.792	0.922	0.777	1.018	....	0.997	0.929	0.895	0.895	0.782	0.727	0.774
5	0.986	0.933	0.790	0.934	0.774	1.018	....	0.999	0.934	0.898	0.882	0.778	0.724	0.778
6	0.991	0.943	0.793	0.937	....	1.024	....	1.001	0.921	0.912	0.889	0.783	0.734	0.772
7	0.989	0.907	....	0.965	....	0.995	....	1.010	0.937	0.928	0.886	0.774	0.741	0.817
8	0.995	0.915	0.806	0.953	....	1.056	....	1.028	0.925	0.925	0.880	0.767	0.746	0.820
9	1.005	0.920	0.811	0.951	....	1.033	....	1.033	0.927	0.943	0.888	0.783	0.754	0.809
10	1.021	0.977	0.795	....	....	1.029	....	1.029	0.928	0.927	0.903	0.783	0.777	....
11	1.022	0.976	0.825	....	....	1.010	....	1.033	0.928	0.936	0.893	0.784	0.803	....
Midn't	1.022	0.923	0.803	....	....	1.013	....	1.003	0.932	0.957	0.875	0.786	0.778	....

TABLE VIII.—*Atmospheric temperature observed at Mount Diablo, March and April,* 1880.

The tabular values are expressed in degrees of Fahrenheit's scale. No correction is required. Values in parenthesis are interpolated.

Hour.	Mar. 21.	Mar. 22.	Mar. 23.	Mar. 26.	Mar. 27.	Mar. 28.	Mar. 29.	Mar. 30.	Mar. 31.	Apr. 6.	Apr. 7.	Apr. 8.	Apr. 9.
A. M.	°	°	°	°	°	°	°	°	°	°	°	°	°
1	....	48.5	49.0	....	30.5	....	....	25.5	33.7	....	....	49.4	52.5
2	....	48.8	48.4	....	30.5	....	....	26.5	34.5	....	....	50.4	52.6
3	....	48.4	48.2	....	....	....	....	25.4	36.6	....	....	49.3	52.0
4	....	47.6	48.0	....	....	....	....	25.5	36.5	....	....	49.6	52.5
5	....	50.0	48.0	....	....	....	....	25.4	(36.3)	....	....	50.5	48.5
6	....	51.4	46.8	25.9	....	....	25.5	26.4	....	....	....	....	50.5
7	....	57.0	47.8	26.5	....	....	26.5	28.7	....	....	....	....	....
8	....	61.0	(50.8)	27.5	....	....	28.5	33.5	....	44.8	....	....	....
9	....	63.4	(52.8)	29.0	....	....	29.8[?]	36.5	39.0	....	....	....	....
10	54.8	64.0	....	30.6	....	....	32.5	39.5	41.5	....	....	54.5	....
11	57.8	63.5	....	34.5	....	....	32.2	42.3	....	....	....	53.6	50.0
Noon	61.8	63.5	....	34.0	....	32.5	37.4	44.5	43.7	....	....	59.0	52.1
P. M.													
1	60.1	63.3	47.8	33.0	....	34.0	39.0	44.0	....	....	60.0	59.9	....
2	58.0	63.8	45.1	36.0	....	35.4	33.0	42.2	....	....	56.9	59.9	....
3	58.1	61.9	41.8	36.3	....	34.8	34.0	43.0	....	....	56.0	57.9	....
4	55.6	62.0	40.8	34.6	....	32.3	32.2	41.4	....	....	55.9	58.0	....
5	53.2	56.9	38.8	32.4	....	32.0	32.2	36.1	....	....	53.7	58.0	....
6	51.0	52.1	40.3	....	....	....	32.0	37.3	....	....	52.6	56.3	....
7	50.0	51.8	39.8	31.9	....	....	(30.0)	37.4	....	....	52.1	56.5	....
8	50.0	51.6	34.0	31.1	....	....	28.0	35.0	....	....	52.0	55.9	....
9	49.0	51.2	....	31.3	....	....	28.0	37.8	....	....	51.8	56.1	....
10	49.8	50.0	....	31.3	....	....	26.7	35.5	....	....	51.4	54.8	....
11	49.4	49.9	....	31.0	....	....	26.9	37.0	....	....	51.9	53.2	....
Midn't	48.9	49.8	....	30.9	....	....	27.2	34.9	....	....	51.0	53.3	....

Hour.	Apr. 10.	Apr. 11.	Apr. 12.	Apr. 13.	Apr. 17.	Apr. 18.	Apr. 19.	Apr. 23.	Apr. 24.	Apr. 25.	Apr. 26.	Apr. 27.	Apr. 28.	Apr. 29.
A. M.	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	....	37.0	33.5	....	....	....	30.5	....	39.0	46.8	44.9	48.5	54.0	59.8
2	....	40.5	32.5	....	....	....	30.6	....	38.3	46.0	44.0	48.8	52.8	59.5
3	....	41.2	....	....	....	....	30.4	....	37.9	46.9	43.0	49.0	52.2	(58.4)
4	....	41.8	32.5	....	....	....	30.0	....	37.2	44.2	43.2	49.5	49.8	57.0
5	....	39.2	....	....	....	....	32.0	....	36.0	44.9	41.0	48.8	50.8	57.2
6	43.5	39.6	....	....	....	27.0	31.2	....	38.9	47.2	(42.3)	50.0	54.0	57.9
7	45.0	40.5	34.0	....	29.0	27.5	31.5	....	40.9	(49.6)	44.9	52.0	60.9	60.3
8	....	42.5	36.3	....	....	29.5	....	....	46.0	52.4	48.8	52.7	64.7	64.7
9	48.8	46.2	....	....	....	(32.2)	....	....	47.6	52.3	52.3	54.2	63.8	64.3
10	45.2	51.6	....	....	....	35.0	....	....	47.7	52.1	57.3	57.8	65.6	69.2
11	49.7	51.5	37.5	....	36.0	35.6	....	....	51.0	51.7	(57.0)	61.2	63.1	69.8
Noon	48.5	49.2	38.5	....	32.5	35.5	....	40.0	53.9	55.0	57.7	62.1	66.1	62.8
P. M.														
1	45.0	....	39.0	....	32.0	37.8	....	43.0	53.8	52.6	57.3	63.2	65.2	65.0
2	46.4	....	....	....	31.8	35.4	....	43.3	54.2	53.9	57.1	62.8	62.6	65.4
3	45.3	....	....	34.0	....	35.2	....	44.0	54.8	54.9	56.1	62.1	61.8	64.9
4	46.9	....	....	33.9	....	34.0	....	43.9	50.3	49.8	54.9	60.2	61.5	65.9
5	43.2	....	....	32.0	....	33.8	....	43.2	47.8	48.2	52.8	56.2	64.6	64.0
6	40.0	....	....	....	....	32.2	....	42.0	47.0	45.0	49.0	54.8	60.8	61.8
7	39.8	....	....	....	....	31.5	....	39.1	47.0	41.8	46.5	55.8	57.8	60.0
8	36.9	....	....	....	....	31.0	....	38.6	46.1	42.9	48.0	53.5	56.8	59.0
9	34.9	34.9	....	....	....	31.0	....	38.1	45.8	45.0	47.0	54.6	56.0	....
10	35.6	33.6	....	....	....	30.5	....	39.0	45.5	44.1	49.0	54.6	56.2	....
11	38.7	33.0	....	....	....	31.4	....	39.5	46.0	44.9	48.2	54.2	58.0	....
Midn't	38.6	33.0	....	....	....	31.1	....	39.2	47.2	44.5	48.0	54.0	59.0	....

TABLE IX.—*Atmospheric temperature observed at Martinez East, March and April,* 1880.

The tabular values are expressed in degrees of Fahrenheit's scale. No correction is required. Values in parenthesis are interpolated
Observations on March 24 and 25, and on April 4 and 22 not tabulated.

Hour.	Mar. 21.	Mar. 22.	Mar. 23.	Mar. 26.	Mar. 27.	Mar. 28.	Mar. 29.	Mar. 30.	Mar. 31.	Apr. 6.	Apr. 7.	Apr. 8.	Apr. 9.
A. M.	°	°	°	°	°	°	°	°	°	°	°	°	°
1	....	45.5	44.8	....	43.9	....	....	39.9	45.9	....	....	52.2	52°.8
2	....	44.2	42.4	....	45.2	....	....	39.7	45.5	....	....	51.9	52.8
3	....	43.6	42.6	....	44.8	....	....	39.7	45.5	....	....	51.1	53.6
4	....	41.5	42.7	....	47.3	....	....	38.2	45.9	....	....	50.7	53.7
5	....	41.3	43.4	....	45.9	....	....	38.6	46.0	....	....	51.3	53.3
6	....	41.6	42.8	40.8	43.8	....	(39.2)	38.1	45.8	....	....	49.4	58.9 [?]
7	....	43.0	44.8	43.5	....	....	41.3	40.1	45.9	....	....	....	53.8
8	....	44.8	46.7	45.1	....	....	44.2	41.8	47.6	....	....	....	55.8
9	....	47.7	47.5	48.2	....	....	46.6	44.8	49.0	....	....	58.8	55.6
10	49.2	48.6	48.8	49.3	....	....	47.9	46.7	52.3	....	....	61.8	58.0
11	55.6	51.4	51.0	50.1	....	....	47.9	48.8	54.3	....	56.9	66.0	61.4
Noon	58.7	55.6	53.0	51.2	....	....	49.3	51.0	56.3	....	60.3	66.7	58.2
P. M.													
1	63.2	60.1	54.2	53.0	....	53.0	51.1	53.0	56.7	....	58.9	68.8	....
2	65.3	61.0	55.8	53.2	....	53.8	53.6	53.2	55.3	....	61.8	68.9	....
3	68.9	64.8	54.8	53.8	....	52.8	54.2	56.3	54.9	....	62.6	71.1	....
4	63.6	64.2	53.1	51.4	....	52.1	53.2	56.1	55.9	....	63.5	68.7	....
5	62.7	63.7	51.7	49.7	....	49.1	49.8	52.4	54.2	....	62.1	67.7	....
6	58.7	59.3	48.6	48.3	....	47.0	47.7	47.9	....	....	56.5	67.9	....
7	57.0	56.3	46.6	45.2	....	....	(44.3)	45.7	....	49.8	56.0	65.0	....
8	55.8	51.9	46.9	45.5	....	43.2	43.2	44.8	....	49.6	55.5	63.7	....
9	51.6	50.2	47.2	45.3	....	....	42.3	44.3	....	48.9	54.8	61.7	....
10	49.1	48.4	48.6	44.8	....	....	41.6	45.1	....	48.4	53.8	54.7	....
11	48.5	46.7	48.9	43.6	....	....	41.6	44.9	....	....	52.7	53.3	....
Midn't	46.2	45.9	48.6	43.2	....	....	40.6	45.2	....	....	53.2	53.4	....

Hour.	Apr. 10.	Apr. 11.	Apr. 12.	Apr. 13.	Apr. 17.	Apr. 18.	Apr. 19.	Apr. 23.	Apr. 24.	Apr. 25.	Apr. 26.	Apr. 27.	Apr. 28.	Apr. 29.
A. M.	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	....	46.7	48.5	43.9	....	....	41.1	....	49.8	45.9	46.3	49.6	49.8	51.1
2	....	46.0	49.1	43.6	....	....	41.9	....	47.8	45.8	46.8	49.2	49.2	50.0
3	....	46.5	48.6	41.8	....	....	42.3	....	47.8	45.3	45.5	48.3	48.4	49.3
4	....	47.2	49.8	41.8	....	....	43.3	....	45.9	44.8	46.2	46.0	46.3	49.3
5	....	48.2	50.5	42.4	....	....	45.1	....	45.3	45.5	45.6	47.7	45.7	49.2
6	43.8	48.3	49.6	42.5	....	....	44.7	42.3	47.1	46.5	47.2	48.3	47.0	49.4
7	47.2	50.0	51.8	44.9	42.8	42.4	(45.0)	45.3	51.2	49.9	51.4	50.8	49.2	52.2
8	48.4	52.3	52.7	48.0	44.0	44.8	43.6	47.3	53.8	53.4	55.1	52.7	51.7	53.9
9	52.1	56.0	53.9	50.0	....	46.0	....	49.5	55.5	55.6	55.2	55.3	53.1	55.2
10	53.7	57.6	56.4	51.4	....	47.8	....	52.0	59.7	59.1	56.1	57.5	56.8	57.0
11	54.4	59.3	57.1	52.2	49.9	49.6	....	54.0	60.9	60.2	58.2	60.3	61.2	59.3
Noon	57.2	65.3	58.9	52.9	52.7	51.6	....	56.2	62.5	60.6	60.9	64.2	67.3	63.6
P. M.														
1	57.6	62.4	59.2	55.2	50.1	55.2	....	58.6	65.8	64.1	63.2	63.3	70.7	64.9
2	58.9	62.5	55.6	54.7	48.4	56.3	....	60.4	68.7	65.0	65.2	65.1	75.1	66.1
3	60.2	61.9	51.6	54.0	49.7	57.1	....	61.0	67.2	65.7	65.9	66.3	74.8	66.8
4	58.9	65.4	50.0	54.8	48.0	55.8	....	60.1	66.7	59.8	67.9	65.2	74.3	67.4
5	56.3	61.7	50.0	51.9	....	51.1	....	60.0	63.2	61.2	65.2	63.9	74.6	64.0
6	52.9	56.0	49.0	50.8	....	48.4	....	58.0	57.7	57.7	61.9	61.3	67.6	60.0
7	50.0	51.6	....	48.2	....	46.1	....	53.6	52.3	52.7	57.5	59.2	59.9	55.9
8	48.2	50.3	45.3	47.3	....	45.0	....	51.7	50.9	50.8	57.0	56.3	57.0	51.8
9	47.4	49.2	45.3	47.3	....	44.3	....	52.7	50.8	49.4	56.6	54.5	55.5	51.3
10	47.7	48.7	44.6	....	....	42.7	....	49.8	48.2	49.4	53.3	53.0	54.6	....
11	46.6	48.1	44.1	....	....	41.6	....	49.7	46.6	47.8	51.7	51.0	53.6	....
Midn't	46.8	48.3	43.4	....	....	39.7	....	48.5	46.5	48.0	50.4	50.5	52.4	....

TABLE X.—*Observations for atmospheric humidity at Mount Diablo, March and April, 1880.*

Readings of wet-bulb thermometer in degrees of Fahrenheit. No correction required. Values in parenthesis are interpolated.

Hour.	Mar. 21.	Mar. 22.	Mar. 23.	Mar. 26.	Mar. 27.	Mar. 28.	Mar. 29.	Mar. 30.	Mar. 31.	Apr. 6.	Apr. 7.	Apr. 8.	Apr. 9.
A. M.	°	°	°	°	°	°	°	°	°	°	°	°	°
1	....	36.3	38.5	....	30.4	....	....	25.6	27.5	....	....	47.5	41.0
2	....	38.2	38.6	....	30.5	....	....	25.8	25.8	....	....	45.3	39.8
3	....	38.2	38.5	....	....	....	....	24.3	32.2	....	....	44.7	41.5
4	....	38.5	37.0	....	....	....	....	23.8	31.9	....	....	45.5	42.5
5	....	38.2	37.0	....	....	....	....	24.0	(33.2)	....	....	46.3	41.5
6	....	39.0	36.0	24.8	....	....	25.5	25.5	....	....	....	....	49.4
7	....	44.4	38.5	25.0	....	....	26.5	27.5	....	....	....	....	....
8	....	46.7	(38.5)	27.0	....	....	28.6	31.0	....	39.8	....	....	....
9	....	48.3	(38.4)	28.5	....	....	30.5	32.0	38.5	....	....	....	....
10	42.5	49.3	....	30.0	....	....	32.0	32.4	40.5	....	....	48.6	....
11	44.7	48.4	....	31.5	....	....	31.8	37.8	....	....	....	47.9	46.8
Noon	47.5	48.7	....	34.0	....	32.0	32.3	39.5	43.0	....	....	48.6	47.0
P. M.													
1	46.8	50.0	38.1	32.0	....	32.0	32.1	38.9	....	....	55.0	57.4	....
2	45.0	50.0	39.8	32.0	....	32.9	32.1	36.9	....	....	53.9	49.9	....
3	45.7	47.7	36.8	34.6	....	34.3	32.3	36.8	....	....	52.6	51.8	....
4	43.0	49.0	37.8	33.8	....	32.1	32.2	36.6	....	....	55.9	54.0	....
5	41.3	46.0	36.4	32.0	....	30.9	31.8	31.5	....	....	52.8	50.3	....
6	39.4	43.2	36.5	....	....	....	30.0	31.9	....	....	47.0	50.0	....
7	38.9	42.0	37.0	32.0	....	....	29.0	32.1	....	....	41.4	50.3	....
8	38.8	41.2	34.0	31.1	....	....	28.0	27.0	....	....	42.0	49.6	....
9	38.2	41.9	....	30.9	....	....	27.8	28.0	....	....	42.5	46.9	....
10	37.8	41.0	....	30.9	....	....	26.5	27.9	....	....	41.6	49.0	....
11	36.9	40.0	....	30.9	....	....	26.5	28.1	....	....	43.0	49.0	....
Midn't	36.8	40.2	....	30.9	....	....	27.2	26.9	....	....	46.0	44.2	....

Hour.	Apr. 10.	Apr. 11.	Apr. 12.	Apr. 13.	Apr. 17.	Apr. 18.	Apr. 19.	Apr. 23.	Apr. 24.	Apr. 25.	Apr. 26.	Apr. 27.	Apr. 28.	Apr. 29.
A. M.	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	....	34.3	31.5	....	....	....	29.8	....	36.5	35.2	38.7	43.8	47.9	43.7
2	....	36.0	30.7	....	....	....	30.5	....	35.7	34.9	38.2	42.7	42.3	43.6
3	....	36.5	....	....	....	....	29.9	....	33.0	34.4	38.1	42.6	42.3	(43.5)
4	....	36.8	32.5	....	....	....	29.4	....	33.0	35.2	37.7	40.9	41.3	43.4
5	....	35.5	....	....	....	....	31.1	....	33.0	35.3	37.2	41.0	41.5	41.9
6	32.2	36.8	....	....	....	26.5	28.8	....	34.9	45.7	(40.2)	43.0	44.0	44.1
7	32.3	38.6	34.0	....	28.0	27.5	29.0	....	36.8	(43.4)	43.2	48.8	48.0	47.3
8	....	40.2	36.0	....	....	29.5	....	....	40.9	41.0	45.8	44.0	49.5	49.4
9	37.5	43.0	....	....	....	(32.0)	....	....	41.9	40.9	47.8	45.9	48.3	50.0
10	37.1	45.8	....	....	....	34.5	....	....	42.3	43.1	51.0	46.5	49.6	53.3
11	41.2	46.4	37.0	....	32.0	35.2	....	....	44.0	42.2	(51.0)	49.0	41.0	54.0
Noon	44.5	45.3	37.5	....	32.0	35.4	....	39.8	46.0	48.2	50.9	50.0	48.9	52.8
P. M.														
1	41.2	....	37.5	....	32.0	36.0	....	41.8	46.0	46.2	50.5	51.6	50.8	52.6
2	39.2	....	....	....	31.5	34.5	....	42.0	47.4	47.7	49.8	52.0	50.2	51.8
3	35.8	....	....	33.9	....	32.7	....	42.9	47.7	48.9	49.0	52.1	46.0	54.3
4	35.3	....	....	33.9	....	32.6	....	42.9	45.4	44.8	49.0	54.9	47.8	51.6
5	35.6	....	....	32.0	....	32.8	....	42.2	42.0	40.8	47.1	52.0	51.8	47.7
6	30.2	....	....	....	....	31.7	....	41.3	40.9	40.6	46.2	44.5	50.2	48.2
7	29.0	....	....	....	....	26.5	....	36.8	39.8	37.5	44.8	44.6	47.0	51.1
8	31.0	....	....	....	....	26.5	....	35.5	39.0	38.9	44.9	43.8	46.8	51.8
9	31.5	34.8	....	....	....	26.2	....	35.3	38.0	40.0	42.5	44.2	44.9	....
10	32.0	31.2	....	....	....	25.7	....	35.0	38.0	41.0	44.2	44.0	44.5	....
11	31.9	31.8	....	....	....	26.4	....	35.0	39.5	40.8	43.8	43.8	43.0	....
Midn't	32.3	30.9	....	....	....	28.3	....	35.3	38.8	39.9	44.1	43.0	42.0	....

TABLE XI.—*Observations for atmospheric humidity at Martinez East, March and April,* 1880.

Readings of wet-bulb thermometer in degrees of Fahrenheit. No correction required. Values in parenthesis are interpolated.

Hour.	Mar. 21.	Mar. 22.	Mar. 23.	Mar. 26.	Mar. 27.	Mar. 28.	Mar. 29.	Mar. 30.	Mar. 31.	Apr. 6.	Apr. 7.	Apr. 8.	Apr. 9.
A. M.	°	°	°	°	°	°	°	°	°	°	°	°	°
1	....	44.9	44.6	....	42.4	....	....	38.7	42.8	....	....	51.7	51.0
2	....	43.2	42.1	....	41.9	....	....	38.7	42.3	....	....	51.5	51.9
3	....	42.3	41.6	....	41.9	....	....	38.6	42.6	....	....	50.6	52.4
4	....	40.9	42.4	....	44.4	....	....	37.3	43.8	....	....	50.5	52.9
5	....	40.5	42.4	....	43.0	....	....	35.9	44.3	....	....	50.7	52.5
6	....	41.2	41.9	37.7	41.3	....	(37.4)	36.4	43.8	....	....	49.4	56.2(?)
7	....	42.7	43.4	39.3	....	....	39.2	38.8	43.1	....	....	....	52.8
8	....	44.6	44.8	40.6	....	....	42.1	37.8	45.0	....	....	....	53.9
9	....	46.3	45.0	42.9	....	....	42.7	40.8	48.4	....	....	57.4	54.0
10	47.6	47.2	45.8	43.7	....	....	43.2	41.6	50.6	....	....	58.9	57.0
11	50.0	49.1	47.3	44.6	....	....	43.8	42.8	51.8	....	54.3	60.7	59.0
Noon	51.9	51.6	48.2	45.4	....	....	43.8	48.2	50.8	....	55.6	61.3	57.8
P. M.													
1	53.1	53.1	48.8	46.5	....	46.3	45.8	49.6	52.1	....	56.2	62.3	....
2	53.7	55.5	49.5	46.7	....	47.8	45.9	45.0	51.5	....	58.7	62.7	....
3	53.8	53.3	48.0	47.0	....	46.7	46.1	45.8	52.6	....	58.8	63.7	....
4	53.4	54.6	47.9	45.2	....	45.4	44.1	47.4	53.6	....	59.6	62.8	....
5	51.9	52.2	47.4	44.7	....	43.7	42.6	45.6	52.5	....	58.3	62.1	....
6	48.7	49.9	45.2	43.8	....	43.0	41.9	42.8	....	....	54.8	61.8	....
7	47.8	49.8	43.5	42.6	....	....	(41.0)	41.3	....	48.0	54.0	61.9	....
8	45.8	48.7	43.8	42.0	....	40.8	40.1	40.8	....	47.8	54.1	60.2	....
9	46.7	47.5	43.8	42.5	....	....	39.8	40.5	....	47.6	53.7	58.7	....
10	46.8	46.6	45.5	42.0	....	....	37.5	41.0	....	46.8	52.8	52.8	....
11	46.6	45.8	44.9	41.6	....	....	39.4	41.0	....	....	52.2	52.1	....
Midn't	45.6	45.6	44.2	41.7	....	....	38.7	41.4	....	....	52.3	51.7	....

Hour.	Apr. 10.	Apr. 11.	Apr. 12.	Apr. 13.	Apr. 17.	Apr. 18.	Apr. 19.	Apr. 23.	Apr. 24.	Apr. 25.	Apr. 26.	Apr. 27.	Apr. 28.	Apr. 29.
A. M.	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	....	45.8	43.4	41.4	....	....	39.6	....	47.5	44.9	45.2	48.7	49.5	50.8
2	....	45.3	45.3	41.3	....	....	40.3	....	47.4	44.6	45.4	48.7	48.8	50.0
3	....	45.4	46.7	40.0	....	....	41.1	....	47.4	44.4	44.4	47.8	48.2	49.3
4	....	46.0	47.3	40.6	....	....	41.9	....	44.9	43.9	45.2	46.6	46.3	49.3
5	....	46.7	47.8	41.0	....	....	42.0	....	44.2	44.3	44.6	46.9	45.5	48.6
6	42.8	46.9	46.8	41.0	....	....	41.6	42.2	45.4	45.0	46.0	47.8	46.8	48.9
7	46.8	48.4	48.5	42.7	40.6	40.2	(41.8)	43.7	49.8	47.8	49.6	50.1	49.2	51.3
8	47.7	51.4	48.0	44.0	40.7	41.8	42.0	45.8	50.8	50.6	51.0	51.6	50.9	53.2
9	49.9	51.7	49.9	45.4	....	41.6	....	47.0	52.0	51.4	52.3	53.5	51.7	54.3
10	50.0	52.7	51.4	48.7	....	42.3	....	48.3	52.9	54.2	53.6	54.9	54.9	55.5
11	51.4	53.8	51.4	48.9	44.0	42.4	....	49.8	53.9	54.0	55.7	56.9	58.0	57.2
Noon	52.7	58.3	52.2	48.6	46.2	44.9	....	51.5	55.8	54.7	57.0	59.4	62.2	59.8
P. M.														
1	53.4	56.3	52.4	49.0	45.0	48.8	....	52.6	54.4	57.6	58.8	58.1	61.9	60.2
2	53.4	57.3	50.8	48.8	44.7	48.9	....	53.2	57.8	57.8	59.8	59.1	64.1	60.6
3	54.3	56.5	49.8	48.5	45.7	49.4	....	53.4	57.0	58.9	59.7	60.2	61.7	60.8
4	53.2	58.2	47.5	47.3	44.3	47.8	....	53.6	56.8	54.5	60.8	60.2	61.6	61.2
5	51.7	55.3	45.0	45.9	....	44.3	....	53.2	53.7	55.0	59.0	58.6	61.2	59.8
6	49.3	53.0	44.0	45.4	....	44.7	....	52.5	52.7	52.7	57.0	58.3	62.2	56.6
7	46.8	47.7	....	44.3	....	42.0	....	48.7	49.3	48.6	53.5	55.6	57.2	52.9
8	45.8	46.8	42.0	44.3	....	41.1	....	47.6	48.5	47.5	52.0	54.0	54.8	50.4
9	45.5	46.3	42.4	44.3	....	40.2	....	47.8	47.5	46.8	50.8	53.3	53.9	49.4
10	45.2	45.3	42.1	....	....	40.2	....	48.2	46.7	47.3	51.3	52.0	53.4	....
11	44.8	44.4	41.5	....	....	39.7	....	47.4	45.0	46.2	51.3	50.3	52.9	....
Midn't	45.8	43.5	41.2	....	....	38.3	....	46.8	45.3	45.9	49.5	50.1	51.8	....

Combination of the meteorological data to obtain a homogeneous series of hourly mean values.—The combination of the broken record of observations into a systematic series of results has been effected precisely in the same way as was followed in the case of the zenith distances, in order

that we may secure a strictly comparable and simultaneous set of data for analysis and discussion. An additional reduction had to be supplied, *i. e.*, for the full hour, the observations at Mount Diablo being about ten minutes and those at Martinez East about five minutes late.

TABLE XII.—*Observations at Mount Diablo, California, March and April,* 1880.

Resulting hourly series of atmospheric pressure (P′).

Hour.	12-day mean series.	*n*.	*n* day resulting series.	Reduced to full hour.	P′.	Hour.	12-day mean series.	*n*.	*n* day resulting series.	Reduced to full hour.	P′.
A. M.	*Inches.*		*Inches.*	*Inches.*	*Millimeters.*	P. M.	*Inches.*		*Inches.*	*Inches.*	*Millimeters.*
1	26.181	16	26.186	26.186	665.12	1	26.223	20	26.218	26.219	665.96
2	.174	16	.180	.181	5.00	2	.217	19	.215	.215	5.86
3	.172	14	.178	.178	4.92	3	.212	18	.207	.208	5.68
4	.168	15	.177	.177	4.90	4	.207	18	.204	.204	5.58
5	.167	13	.171	.172	4.77	5	.198	18	.193	.195	5.36
6	.174	15	.173	.173	4.79	6	.195	15	.194	.194	5.33
7	.179	17	.175	.175	4.84	7	.198	17	.192	.192	5.28
8	.186	14	.185	.183	5.05	8	.203	16	.202	.200	5.48
9	.188	14	.196	.194	5.33	9	.206	16	.200	.200	5.48
10	.225	14	.225	.220	5.99	10	.199	16	.194	.195	5.35
11	.225	16	.227	.227	6.17	11	.198	16	.191	.191	5.25
Noon	.231	19	.225	.225	6.11	Midn't	.192	16	.186	.187	5.15

TABLE XIII.—*Observations at Martinez East.*

Resulting hourly series of atmospheric pressure (P).

Hour.	12-day mean series.	*n*.	*n* day resulting series.	Reduced to full hour.	P.	Hour.	12-day mean series.	*n*.	*n* day resulting series.	Reduced to full hour.	P.
A. M.	*Inches.*		*Inches.*	*Inches.*	*Millimeters.*	P. M.	*Inches.*		*Inches.*	*Inches.*	*Millimeters.*
1	29.931	16	29.939	29.938	760.43	1	29.968	20	29.960	29.960	760.98
2	.923	16	.931	.931	0.25	2	.951	19	.945	.946	0.63
3	.922	14	.926	.926	0.12	3	.936	18	.929	.930	0.22
4	.915	15	.923	.923	0.04	4	.925	18	.921	.923	760.02
5	.923	13	.926	.926	0.12	5	.924	18	.919	.919	759.94
6	.942	15	.936	.935	0.35	6	.930	15	.922	.922	760.02
7	.944	17	.938	.938	0.43	7	.928	17	.922	.922	0.02
8	.946	14	.944	.944	0.58	8	.934	16	.927	.927	0.15
9	.950	14	.954	.953	0.81	9	.942	16	.934	.933	0.30
10	.977	14	.976	.974	1.34	10	.942	16	.938	.938	0.43
11	.970	16	.972	.972	1.29	11	.943	16	.941	.941	0.50
Noon	.978	19	.960	.961	1.01	Midn't	.936	16	.931	.932	0.27

TABLE XIV.—*Observations at Mount Diablo, California, March and April,* 1880.

Resulting hourly series of atmospheric temperature (T′).

Hour.	12-day mean series.	*n*.	*n* day resulting series.	Reduced to full hour.	T′.	Hour.	12-day mean series.	*n*.	*n* day resulting series.	Reduced to full hour.	T′.
A. M.	° *F.*		° *F.*	° *F.*	° *C.*	P. M.	° *F.*		° *F.*	° *F.*	° *C.*
1	43.10	16	43.19	43.23	+6.24	1	52.03	20	51.28	51.27	+10.70
2	43.23	16	43.29	43.27	6.26	2	51.07	19	50.65	50.75	10.42
3	43.13	14	43.05	43.09	6.17	3	50.93	18	50.21	50.28	10.16
4	42.58	15	42.67	42.73	5.96	4	49.40	18	49.44	49.57	9.75
5	42.47	13	42.41	42.45	5.80	5	47.35	18	47.03	49.43	8.58
6	42.69	15	42.93	42.84	6.02	6	45.27	15	45.50	45.75	7.64
7	45.96	17	45.14	44.77	7.09	7	44.03	17	44.28	44.48	6.93
8	47.[illegible]	14	47.59	47.18	8.43	8	43.20	16	43.81	43.89	6.61
9	48.80	14	49.51	49.19	9.56	9	43.20	16	43.56	43.60	6.44
10	51.73	14	51.67	51.81	10.72	10	43.03	16	43.25	43.30	6.28
11	52.00	16	52.54	52.40	11.33	11	43.67	16	43.60	43.54	6.41
Noon	52.17	19	51.20	51.42	10.80	Midn't	43.58	16	43.44	43.47	6.37

TABLE XV.—*Observations at Martinez East, California.*

Resulting hourly series of atmospheric temperature (T).

Hour.	12-day mean series.	n.	n day resulting series.	Reduced to full hour.	T.	Hour.	12-day mean series.	n.	n day resulting series.	Reduced to full hour.	T.
A. M.	° F.		° F.	° F.	° C.	P. M.	° F.		° F.	° F.	° C.
1	46.37	16	46.07	46.15	+7.86	1	60.50	20	59.92	59.76	+15.43
2	45.70	16	45.68	45.71	7.62	2	62.32	19	61.52	61.39	16.33
3	45.40	14	45.29	45.32	7.40	3	63.53	18	62.74	62.64	17.03
4	44.85	15	44.95	44.98	7.21	4	62.15	18	61.80	61.88	16.60
5	45.13	13	44.99	44.99	7.21	5	60.83	18	59.71	59.88	15.49
6	45.02	15	45.60	45.55	7.53	6	56.60	15	56.61	56.87	13.81
7	47.40	17	48.00	47.80	8.78	7	52.88	17	52.89	53.20	11.78
8	49.60	14	49.74	49.60	9.78	8	51.05	16	51.29	51.42	10.79
9	51.22	14	51.60	51.45	10.80	9	49.97	16	50.24	50.33	10.18
10	53.33	14	53.61	53.44	11.91	10	48.57	16	48.63	48.76	9.31
11	55.65	16	56.04	55.84	13.25	11	47.53	16	47.58	47.67	8.70
Noon	57.93	19	57.96	57.80	14.33	Midn't	46.73	16	47.00	47.05	8.36

TABLE XVI.—*Observations at Mount Diablo, California, March and April,* 1880.

Resulting hourly series for atmospheric humidity, temperature of wet bulb (t').

Hour.	12-day mean series.	n.	n day resulting series.	Reduced to full hour.	t'.	Hour.	12-day mean series.	n.	n day resulting series.	Reduced to full hour.	t'.
A. M.	° F.		° F.	° F.	° C.	P. M.	° F.		° F.	° F.	° C.
1	36.48	16	36.48	36.43	+2.46	1	44.32	20	44.01	43.97	+6.65
2	36.25	16	36.05	36.12	2.29	2	43.90	19	43.42	43.52	6.40
3	36.12	14	36.00	36.01	2.23	3	43.09	18	43.11	43.16	6.20
4	35.74	15	35.93	35.94	2.19	4	42.81	18	43.17	43.16	6.20
5	35.74	13	35.80	35.82	2.12	5	41.24	18	41.05	41.40	5.22
6	36.96	15	37.23	36.99	2.77	6	39.18	15	39.22	39.52	4.18
7	39.34	17	38.82	38.56	3.64	7	37.34	17	37.86	38.09	3.38
8	40.42	14	40.20	39.97	4.42	8	36.78	16	37.39	37.47	3.04
9	41.12	14	41.08	40.93	4.96	9	36.54	16	36.60	36.73	2.63
10	42.80	14	42.82	42.53	5.85	10	36.46	16	36.39	36.43	2.46
11	43.36	16	43.33	43.25	6.25	11	36.31	16	36.40	36.40	2.44
Noon	44.31	19	43.77	43.70	6.50	Midn't	36.24	16	36.18	36.22	2.34

TABLE XVII.—*Observations at Martinez East, California.*

Resulting hourly series for atmospheric humidity, temperature of wet bulb (t).

Hour.	12-day mean series.	n.	n day resulting series.	Reduced to full hour.	t.	Hour.	12-day mean series.	n.	n day resulting series.	Reduced to full hour.	t.
A. M.	° F.		° F.	° F.	° C.	P. M.	° F.		° F.	° F.	° C.
1	45.25	16	44.84	44.88	+7.16	1	53.94	20	53.48	53.43	+11.90
2	44.74	16	44.58	44.60	7.00	2	54.52	19	54.22	54.16	12.31
3	44.42	14	44.26	44.29	6.83	3	54.46	18	54.23	54.23	12.35
4	44.04	15	44.15	44.16	6.76	4	54.00	18	53.91	53.94	12.19
5	43.82	13	43.69	43.73	6.52	5	52.41	16	52.43	52.55	11.42
6	43.78	15	44.07	44.04	6.69	6	51.06	15	51.08	51.19	10.66
7	46.01	17	46.36	46.18	7.88	7	48.46	17	48.61	48.82	9.34
8	47.55	14	47.51	47.41	8.56	8	47.22	16	47.50	47.59	8.66
9	48.46	14	48.63	48.54	9.19	9	46.69	16	47.01	47.05	8.36
10	49.82	14	49.93	49.82	9.90	10	46.35	16	46.23	46.29	7.94
11	51.26	16	51.38	51.26	10.70	11	45.86	16	45.71	45.75	7.64
Noon	52.81	19	52.87	52.75	11.53	Midn't	45.40	16	45.29	45.33	7.40

Before proceeding with the investigation of the atmospheric refraction in connection with heights determined by zenith distances, it will be convenient first to present the results for difference of height as deduced from the observed pressure and temperature of the atmosphere at the two stations.

BAROMETRIC DIFFERENCE OF HEIGHT.—For the computation of the hourly series of barometric observations I propose to use the formula given by Dr. Jordan* in preference to that given by Dr. Rühlmann,† for the reason that the first-named formula, with the same strictness, is somewhat easier of application, besides it will facilitate the discussion of the atmospheric refraction in connection with a theory published by Dr. Jordan in the Astronomische Nachrichten No. 2095 (1876), and which will be referred to in connection with our observations at Mount Diablo–Martinez East.

It is as follows:

$$\triangle h = 18400 \log \frac{P}{P'} (1 + .003665\, t) \left(1 + .377 \frac{e}{p}\right) (1 + .002573 \cos 2\varphi) \left(1 + \frac{2H}{r}\right)$$

where P′ and P are the observed pressures at the upper and lower station, respectively; these values must be corrected for variation in gravity with latitude and altitude *before* introducing their values into the formula. A table is provided giving this reduction, with the arguments, pressure (in millimeters), and approximate height of station above the sea (in meters).

t represents the mean atmospheric temperature at the upper and lower stations, or the value $\frac{T + T'}{2}$ expressed in centigrade degrees.

e represents the mean vapor pressure, and p the mean atmospheric pressure at the stations. A table is provided for finding e when the readings of the dry and the wet bulb thermometers are given.

φ is the mean latitude, and H the average height of the two stations above the sea.

r stands for the earth's mean radius, roughly equal to 6370000 meters.

$\triangle h$ is the resulting difference of height in meters.

The logarithms of each of the four terms in parenthesis are obtained from tables accompanying the formula.

The results of the computation are presented in the following table, in which, for comparison, we have also introduced the results of Rühlmann's formula. The column headed "Required mean temperature" shows the temperature which is demanded by the barometric formula, in order to satisfy the condition of giving the true height as found by spirit-leveling.

TABLE XVIII.

Hour.	Values of Δh computed by Jordan's formula.	Values of Δh computed by Rühlmann's formula.	Error in value of Δh.	Observed mean temperature t.	Required mean temperature τ.	Apparent error in mean temperature t.
A. M.	*Meters.*	*Meters.*	*Meters.*	° *C.*	° *C.*	° *C.*
1	1104.4	1103.6	−11.7	+7.05	+10.00	−2.95
2	03.4	02.6	12.7	6.94	10.15	3.21
3	02.4	01.5	13.7	6.78	10.25	3.47
4	01.0	00.1	15.1	6.58	10.40	3.82
5	03.1	02.3	13.0	6.50	9.79	3.29
6	06.6	05.7	9.5	6.78	9.18	2.40
7	11.7	10.8	4.4	7.94	9.05	1.11
8	15.3	14.5	− 0.8	9.10	9.30	−0.20
9	18.6	17.8	+ 2.5	10.18	9.54	+0.64
10	20.8	19.9	4.7	11.32	10.18	1.19
11	21.9	21.0	5.8	12.29	10.83	1.46
Noon	20.9	20.0	4.8	12.56	11.35	1.21

* Handbuch der Vermessungskunde von Dr. W. Jordan: Stuttgart, 1877, vol. 1, p. 493.

† Die Barometrischen Höhenmessungen von Dr. R. Rühlmann: Leipzig, 1870.

TABLE XVIII—Continued.

Hour.	Values of Δh computed by Jordan's formula.	Values of Δh computed by Rühlmann's formula.	Error in value of Δh.	Observed mean temperature t.	Required mean temperature τ.	Apparent error in mean temperature t.
P. M.	*Meters.*	*Meters.*	*Meters.*	° C.	° C.	° C.
1	24.5	23.6	8.4	13.06	10.94	2.12
2	23.1	22.1	7.0	13.38	11.60	1.78
3	21.6	20.6	5.5	13.60	12.20	1.40
4	19.0	18.0	2.9	13.18	12.43	0.75
5	16.2	15.3	+ 0.1	12.04	12.01	+0.03
6	12.2	11.3	− 3.9	10.72	11.71	−0.99
7	07.3	06.4	8.8	9.36	11.61	2.25
8	03.5	02.5	12.6	8.70	11.91	3.21
9	03.5	02.6	12.6	8.31	11.51	3.20
10	04.5	03.6	11.6	7.80	10.73	2.93
11	05.5	04.6	10.6	7.56	10.24	2.68
Midn't	03.5	02.7	−12.6	7.36	10.56	−3.20
Mean	1111.4	1110.5		+9.54	+10.73	
True h	1116.1					

We notice the following facts:

(1.) The barometric measures give the difference of height, on the daily average, 4.7 meters in defect (error 1 in 237 meters), whereas the measure of reciprocal and simultaneous zenith distances made the difference in height on the daily average 1.96 meters in excess (error 1 in 569 meters). Between the results by Jordan's and Rühlmann's formulæ there is a difference of 0.9 meter ± 0.1 meter, the first set having slightly the advantage over the second. This difference is not greater than might be expected between any two formulæ aiming at great precision.

(2.) The computed hourly heights exhibit the usual excess over the true value during the warmer part of the day and the usual deficiency during the colder part.

(3.) Diurnal range in values of h, 23.5 meters. Times when correct values are reached, 8¼ a. m. and 5 p. m. The range is of average magnitude (about one forty-seventh of the height), and the hours most favorable for barometric measures according to Rühlmann—7¾ a. m. and 6½ p. m. (for March and April)—do not differ more from the above hours than could be accounted for by ordinary variability.

(3.) The temperature required in order that the true difference of height may result shows less diurnal range (3°.4) than is observed at either station (mean range 7°.1), and the mean value for the day (10°.73) approximates nearer to the mean temperature of the day at the lower station (+ 11°.15 C.) than to that of the upper station (+ 7°.94 C.).

On the immediate sea-coast, as at Bodega Head and Ross Mountain, the computed diurnal range of the temperature of the intervening stratum of air was too small to be perceptible between the hours 7 a. m. and 5 p. m., the observations being discontinued during the night. At Martinez East and Mount Diablo, about 50 kilometers (say 30 statute miles) from the coast, the range is two-fifths of the range as observed near the surface of the ground, and farther in the interior, or in the California Valley, the difference between the observed and required temperature of the air between two stations will undoubtedly be found to become still less.

The effect of a small error in the mean temperature of the air on the computed height (h) is given by the equation

$$dh = \frac{\epsilon}{1 + \epsilon t} h dt$$

and putting $\epsilon = .003665$, $t = + 10°$ C., and $h = 1116$ meters, we find $dh = 3.95 dt$, or an effect of nearly 4 meters for a change of 1° in the temperature.

(4.) The last column, headed apparent error in mean temperature t, contains also the apparent error of the observed temperatures at the two stations, supposing them affected alike; that this equality, however, does not hold is proved by the anomaly that the observed temperatures at Mount Diablo, when thus corrected, would show higher temperatures (by about 1°) during the night than during the day; in fact the distribution of the error as given in that column is unequal as regards the two stations, and the lower one is undoubtedly much more affected than the upper one. The numbers plainly show that during the hours of insolation, between 9 a. m. and 5 p. m., the observed temperatures are too high by fully 2° C. in maximo (at 1 p. m.), and during the other hours they are too low by fully $3\frac{3}{4}$° C. in maximo (at 4 a. m.). Applied with reversed sign as corrections, the numbers in this column may advantageously be applied to other barometric measures in the same climatic region, especially if attention be paid to unequal distribution for the two stations. The correction to t of $\frac{1}{12}(n_2 - n_1) \triangle h$, as proposed by Dr. Jordan, where n_2 n_1 equal the rate of change of temperature with height at the upper and lower station (as explained further on), does not appear to be sustained in our case, certainly not during the night hours, and roughly only for a few hours near noon.

APPLICATION TO HYPSOMETRY OF DR. VON. BAUERNFEIND'S THEORY OF ATMOSPHERIC REFRACTION AND COMPARISON WITH OBSERVATIONS AT MOUNT DIABLO–MARTINEZ EAST.— For reference to this theory, which makes use of the meteorological condition of the atmosphere in connection with an expression for the curvature of the path of light between two stations where reciprocal zenith distances have been measured, see Astronomische Nachrichten, Nos. 1478–1480 (vol. 62, 1864), and Nos. 1587–1590 (vol. 67, 1866), and formulæ and application of the same in Coast Survey Report for 1876, Appendix No. 16, where I have applied it to the case of hypsometric researches at Bodega Head and Ross Mountain, California. This theory enables us to compute the difference of height from the measured zenith distances and the observed barometric pressure and the temperature and humidity of the air at each station, and two results can be given, one from the observations at the upper and one from the observations at the lower station. It would be needless to repeat here the formulæ and their explanation, as they can be conveniently referred to in the report for 1876, inasmuch as the results deduced do not fully come up to the expectations which might be demanded from such a theory, and the cause of this shortcoming would seem to lie in the circumstance that the theory has not sufficient flexibility to accommodate itself to the various physical conditions existing at the time. The results and comparisons are given in the following tables:

TABLE XIX.—*Comparison of Bauernfeind's theory of refraction with observations at Mount Diablo and Martinez East.*

Hour.	Computed difference of height from observed zenith distances.			True minus mean $\triangle h$.	Improvement in theory of equal refraction at the stations.	Computed refraction at Mount Diablo.	Computed refraction at Martinez East.	Observed minus computed refraction at Mount Diablo.	Observed minus computed refraction at Martinez East.	Computed difference in angle of refraction, lower–upper station.	Same observed (see Table V).	Computed coefficient of refraction.	
	At Mount Diablo.	At Martinez East.	Mean.									At Mount Diablo.	At Martinez East.
A. M.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	"	"	"	"	"	"		
1	1115.98	1120.34	1118.16	--2.07	0.26	69.1	70.9	−1.5	+36.2	+1.8	+39.5	0.086	0.089
2	15.98	20.47	18.22	2.13	.26	69.0	71.0	−1.3	+37.2	+1.9	40.5	6	9
3	15.69†	20.82*	18.26*	2.17*	.25	69.1	71.0	+1.0†	+40.3*	+2.0	41.2*	6	9
4	15.78	20.44	18.11	2.02	.26	69.2	71.1*	+0.2	+37.1	+1.9	38.8	6	9
5	15.89	20.44	18.16	2.07	.26	69.2*	71.1	−0.6	+37.1	+1.9	39.6	6	9
6	16.15	19.97	18.06	1.97	.27*	69.1	71.0	−2.9	+33.1	+1.9	37.9	6	9
7	15.99	19.68	17.84	1.75	.25	68.5	70.4	−1.4	+30.5	+1.9	33.8	6	8
8	16.08	19.10	17.59	1.50	.26	67.9	69.9	−2.2	+25.6	2.1	29.8	5	8
9	16.26	18.95	17.60	1.51	.27	67.4	69.5	−3.7	+24.3	+2.1*	30.1	4	7
10	16.60	18.77	17.68	1.59	.27	67.0	69.0	−6.6	+22.8	+2.1	31.4	4	7
11	17.09	18.34	17.72	1.63	.23	66.7	68.4	−10.6	+19.1	+1.6	31.4	4	6
Noon	17.35	18.01	17.68	1.59	.17	67.1	67.8	−12.9	+16.3	+0.8	29.9	4	5

N. B.—An asterisk (*) indicates a maximum and a dagger (†) a minimum value.

TABLE XIX.—*Comparison of Bauernfeind's theory of refraction with observations at Mount Diablo and Martinez East*—Continued.

Hour.	Computed difference of height from observed zenith distances— At Mount Diablo.	At Martinez East.	Mean.	True minus mean Δh.	Improvement in theory of equal refraction at the stations.	Computed refraction at Mount Diablo.	Computed refraction at Martinez East.	Observed minus computed refraction at Mount Diablo.	Observed minus computed refraction at Martinez East.	Computed difference in angle of refraction, lower-upper station.	Same observed (see Table V).	Computed coefficient of refraction. At Mount Diablo.	At Martinez East.
P. M.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	"	"	"	"	"	"		
1	17.56	17.72	17.64	−1.55	.14	67.1†	67.3	−14.7	+13.8	+0.3	28.7	4	4
2	17.84*	17.52†	17.68	1.59	.10	67.2	66.8	−17.0*	+12.1	−0.3	28.7	4	4
3	17.77	17.53	17.65	1.56	.07	67.3	66.5†	−16.4	+12.1†	−0.8	27.7	4	3
4	17.83	17.65	17.74	1.65	.09	67.5	66.7	−17.0	+13.1	−0.6	29.3	4	3
5	17.52	17.69	17.60	1.51	.09	68.1	67.2	−14.5	+13.5	−0.9	27.1	5	4
6	16.95	18.16	17.55†	1.46†	.12	68.5	68.0	− 9.6	+17.6	−0.5	26.7†	6	5
7	16.49	18.70	17.60	1.51	.15	68.8	69.0	− 5.7	+22.2	+0.1	28.1	6	6
8	16.39	19.08	17.74	1.65	.16	69.0	69.4	− 4.9	+25.4	+0.4	30.7	6	7
9	16.30	19.57	17.94	1.85	.18	69.1	69.7	− 4.2	+29.6	+0.7	34.4	6	8
10	16.29	19.79	18.04	1.95	.21	69.1	70.2	− 4.0	+31.5	+1.1	36.6	6	8
11	16.13	20.12	18.12	2.03	.24	69.0	70.5	− 2.7	+34.3	+1.5	38.5	6	8
Midn't	16.08	20.10	18.09	−2.00	.24	69.0	70.6	− 2.3	+34.1	+1.6	38.0	6	9
Mean	1116.58	1119.12	1117.85		0.20	68.3	69.3			+1.0	+33.3	0.085	0.087
	True Δ *h* by spirit-level		1116.00									Required by Table V.	
	Mean difference		1.76									0.079	0.121

N. B.—An asterisk (*) indicates a maximum and a dagger (†) a minimum value.

The results of the comparison, as shown in Table XIX, indicate but a slight improvement ($0^m.20$) in the computed difference of height, while the departures from the true angle of refraction at both stations (and consequently also in the coefficients of refraction) exhibit most conspicuously a want of accord with facts as observed at Mount Diablo and Martinez East; thus, computed range of angle of refraction at the upper station 2''.15, observed range, 19''.9 (Table V); same for the lower station, computed, 4''.66, observed, 32''.7. Columns 11 and 12 of the preceding table show the discord in the computed and observed difference in the angles of refraction, while in columns 13 and 14 the smallness of the range of diurnal variation in the coefficients of refraction is prominently brought out. The theory assumes a uniform decrease of the atmospheric temperature with an increase of altitude, about 0°.58 C. for each 100 meters, a condition which does not hold good in any particular case, and probably the fundamental relation postulated between absolute temperature and density of air is not in sufficient accord with facts. It is, however, certain that the atmospheric temperatures observed *near the ground* are seriously affected by this circumstance and must lead to faulty conclusions respecting the temperature of the stratum of air intervening between the stations.

We now proceed to test another theory of refraction, in which special attention is given to the rate of decrease of temperature with increase of height.

APPLICATION AND COMPARISON WITH OBSERVATION OF DR. JORDAN'S THEORY OF REFRACTION IN CONNECTION WITH HYPSOMETRY.—Referring for the development of this theory to the author's "Handbuch" cited above, we at once transfer the leading expressions required for application; they are the following:

From the computation of the barometric observati ons for height we take the value

$$K = 18400\left(1 + .377\frac{e}{p}\right)\ (1 + .002573\cos 2\varphi)\ \left(1 + \frac{2H}{r}\right)$$

and adopting the notation, for the lower and upper station, respectively:

P_1 P_2 = the atmospheric pressure expressed in millimeters and height of column of mercury reduced to temperature 0° C., and referred to intensity of gravity in latitude 45° and to the sea-level,

T_1 T_2 = the atmospheric temperature expressed in degrees of the centigrade scale,

n_1 n_2 = the change of temperature of the air at the stations for unit of height (or for one meter),

k_1 k_2 = values, in general, of the coefficient of refraction, k' k'' special values of the same (half of this value is regarded on the survey as the coefficient of refraction),

$\triangle z_1$ $\triangle z_2$ = angle of refraction,

ζ_1 ζ_2 = measured zenith distances,

h_1 h_2 = altitudes of the stations above the sea, in meters,

with the following constants:

$$c = \frac{.00029286}{760}; \ \log c = 3.58585 - 10,$$

$M = .43429$, the modulus of common logarithms; $\log M = 9.63778 - 10$,

$\varepsilon = .003665$, the coefficient of expansion of air,

ψ = angle at earth's center, between verticals to stations, or $\frac{s}{\rho \sin 1''}$, when expressed in seconds,

ρ = radius of curvature to intervening horizontal arc at sea-level,

$s_{,}$ = the length of this arc at an altitude of H, or $\frac{h_1 + h_2}{2}$ above the sea $= s\ \frac{\rho + H}{\rho}$,

$r = \rho + H$,

we then have

For lower station:

$$k_1 = c\ \frac{P_1}{1 + \varepsilon T_1}\left(\frac{1 - \varepsilon T_1}{MK} - n_1\right) r$$

For upper station:

$$k_2 = c\ \frac{P_2}{1 + \varepsilon T_2}\left(\frac{1 - \varepsilon T_2}{MK} - n_2\, \varepsilon\right) r$$

$$k' = \frac{2k_1 + k_2}{3} \qquad \triangle z_1 = \frac{k'}{2}\psi$$

and

$$k'' = \frac{2k_2 + k_1}{3} \qquad \triangle z_2 = \frac{k''}{2}\psi$$

In case the separate values n_1 n_2 are not obtainable, we have to put

$$n_1 = n_2 = \frac{T_1 - T_2}{\triangle h}$$

but supposing that reciprocal and simultaneously observed zenith distances are on hand, these values may be determined by inversion of the formulæ involving k_1 k_2 k' k'', and deducing n_1 n_2 from the known values $\triangle z_1$ $\triangle z_2$.

The difference of height $\triangle h$ is then found by either expression

$$h_2 - h_1 = s_{,} \cot\,(\zeta_1 + \triangle z_1) + \frac{s_{,}^2}{2r} \qquad h_1 - h_2 = s_{,} \cot\,(\zeta_2 + \triangle z_2) + \frac{s_{,}^2}{2r}$$

Or by

$$h_2 - h_1 = s_{,} \cot \zeta_1 + \frac{1 - k'}{2r}\, s_{,}^2 \qquad h_1 - h_2 = s_{,} \cot \zeta_2 + \frac{1 - k''}{2r}\, s_{,}^2$$

Applying these formulæ to the observations on hand and putting $n_1 = n_2 = n$ we have the results of

TABLE XX.—*Comparison of Jordan's theory of refraction with observations at Mount Diablo and Martinez East.*

Hour.	Computed difference of height from observed zenith distances. At Mount Diablo.	At Martinez East.	Mean.	True minus mean Δh.	Improvement on theory of equal refraction at the stations.	Computed refraction at Mount Diablo.	Computed refraction at Martinez East.	Observed minus computed refraction at Mount Diablo.	Observed minus computed refraction at Martinez East.	Computed difference in angle of refraction lower-upper station.	See observed value Table V.)	Computed coefficient of refraction. ½k' Mount Diablo.	½k' Martinez East.
A. M.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meter.*	"	"	"	"	"	"		
1	1117.20	1119.28	1118.24	−2.15	0.18	76.2	79.3	− 8.6	+27.8	+3.1	+39.5	.097	.101
2	7.26	9.33	8.29	2.20	.19	76.8	79.9	− 9.1	+28.3	+3.1	40.5	.098	.102
3	7.02	9.64*	8.33*	2.24*	.18	77.2	80.4	− 7.1	+30.0	+3.2	41.2	.098	.102
4	7.10	9.28	8.19	2.10	.18	77.2	80.4	− 7.8	+27.8	+3.2	38.8	.098	.102
5	7.16	9.31	8.23	2.14	.19	76.9	80.1	− 8.3	+28.1	+3.2	39.6	.098	.102
6	7.41	8.88	8.14	2.05	.19	76.6	79.7	−10.4	+24.4	+3.1	37.9	.097	.101
7	7.17	8.63	7.90	1.81	.19	75.5	78.6	− 8.4	+22.3	+3.1	33.8	.096	.100
8	7.34	7.91	7.62	1.53	.23*	75.5	78.7	− 9.8	+16.8	+3.2	29.8	.096	.100
9	7.54	7.83	7.68	1.59	.19	75.2	78.3	−11.5	+15.5	+3.1	30.1	.096	.100
10	7.88	7.64	7.76	1.67	.19	74.8	77.9	−14.4	+13.9	+3.1	31.4	.095	.099
11	8.14*	7.40†	7.77	1.68	.18	72.7	75.6	−16.6	+11.9	+2.9	31.4	.093	.096
Noon	7.95	7.46	7.70	1.61	.15	69.2	71.7	−15.0	+12.4	+2.5	29.9	.088	.091
P. M.													
1	7.86	7.46	7.66	1.57	.12	66.6	68.7	−14.2	+12.4	+2.1	28.7	.085	.088
2	7.80	7.54	7.67	1.58	.11	63.9	65.8	−13.7	+13.1	+1.9	28.7	.081	.084
3	7.48	7.78	7.63	1.54	.09†	61.9	63.5	−11.0	+15.1	+1.6	27.7	.079	.081
4	7.55	7.90	7.72	1.63	.11	62.1	63.7	−11.6	+16.1	+1.6	29.3	.079	.081
5	7.23	7.95	7.59	1.50	.10	62.5	64.2	− 8.9	+16.5	+1.7	27.1	.080	.082
6	6.88	8.24	7.56†	1.47†	.11	64.8	66.6	− 5.9	+19.0	+1.8	26.7	.083	.085
7	6.79†	8.45	7.62	1.53	.13	68.2	70.4	− 5.1	+20.8	+2.2	28.1	.087	.090
8	6.88	8.64	7.76	1.67	.14	70.0	72.4	− 5.9	+22.4	+2.4	30.7	.089	.092
9	6.91	9.03	7.97	1.88	.15	71.1	73.6	− 6.2	+25.7	+2.5	34.4	.091	.094
10	7.10	9.10	8.10	2.01	.15	72.9	75.6	− 7.8	+26.1	+2.7	36.6	.093	.096
11	7.16	9.23	8.19	2.10	.17	74.6	77.4	− 8.3	+27.4	+2.8	38.5	.095	.099
M dn't	7.20	9.11	8.15	−2.06	.18	75.3	78.3	− 8.6	+26.4	+3.0	38.0	.096	.100
	1117.33	1118.46	1117.89		.16	71.6	74.2			+2.6	+33.3	.091	.095
		True value	1116.09									Required by Table V.	
												.079	.121

Comparing the contents of Tables XIX and XX we find but little difference in the hourly values of resulting difference of height, the two theories giving about the same result; with respect to the angle of refraction, however, there is a considerable difference, the errors in the angles being more equally distributed between the two stations in Jordan's than in the Bauernfeind's theory. We also notice a marked improvement in the diurnal variation of the coefficient of refraction as given in Table XX, and which compares more favorably with the results m_0 of Table V. The more important part of the theory is that involving the rate of change of temperature with increase of height. These results are given in Table XXI.

TABLE XXI.—*Rate of change of temperature with altitude for the stratum of air between Martinez East and Mount Diablo.*

Hour.	n_1 Martinez East.	n_2 Mount Diablo.	Mean n. $\frac{n_1+n_2}{2}$	Observed. $\frac{T_1-T_2}{\Delta h}$	Computed minus observed. Δn.
A. M.	°	°	°	°	°
1	—.0231	+.0210	—.0010	+.00145	—.0024
2	.0238	.0214	12	122	— 24
3	.0252	.0207	22	110	— 33
4	.0231	.0199	16	112	— 27
5	.0234	.0207	13	126	— 26
6	.0212	.0209	02	135	— 16
7	.0188	.0185	— 02	151	— 17
8	.0155	.0172	+ 08	121	— 04
9	.0153	.0180	14	111	+ 03
10	.0153	.0199	23	107	+ 12
11	.0140	+.0216	38	172	+ 21
Noon.	—.0124	.0219	+ 48	316	+ 16
P. M.					
1	—.0110	+.0222	+ 56	424	+ 14
2	.0105	.0232	64	530	11
3	.0101	.0225	62	616	00
4	.0111	.0234	61	614	00
5	.0103	.0213	55	619	— 07
6	.0116	.0190	37	553	— 18
7	.0138	.0179	20	434	— 23
8	.0159	.0186	14	374	— 23
9	.0189	.0200	06	335	— 27
10	.0203	.0208	+ 02	271	— 25
11	.0221	.0211	— 05	205	— 25
Midn't	—.0218	+.0208	—.0005	+.00178	— 23
Mean	—.0170	+.0205	+.0018	+.00287	—.0011

These tabular results are remarkable and would have been unexpected but for the large observed difference in the angles of refraction at the lower and upper station (as shown in Table V). First, we notice that at the lower station the temperature rises (sign of n_1 negative) with the altitude, which might be explained by the continued influx at a low level of cold air through the Golden Gate and with an effect much greater during the hours of night than during the hours of daylight. A rise in temperature with rise in altitude is not noted here for the first time; in the discussion of the observations at the stations Kupferkuhle and Brocken, as given by Dr. Jordan, there is an increase of temperature with height at the earliest hour of observation ($6^h\,35^m$) in the morning, and had the observations been continued during the night the law of the diurnal variation would then necessarily have given negative values of n. The same occurred in the observations at Bodega Head and Ross Mountain, as presented by Captain H. Hartl,* who, in 1881 reviewed the article in the Coast Survey Report for 1876, Appendix No. 16, containing the discussion of the observations made at these stations by Assistant Davidson in March, 1860. His results being supplementary to our article I transfer them to this paper. It will be seen that Captain Hartl extended the comparison of mean temperatures, as observed and required, to the temperatures at each station, thus: let $\tau_1\ \tau_2$ be the required or true temperature of the air immediately resting on the lower and upper station as derived from the inversion of the barometric formula (see values of $\frac{1}{2}(\tau_1+\tau_2)$ in column 6 of Table XVIII for the case Martinez East and Mount Diablo), which gives $\tau_1+\tau_2$. A value for the difference $\tau_1-\tau_2$ is obtained by multiplying the average rate of change of temperature or $\frac{1}{2}(n_1+n_2)$ by the difference of height which gives the total change of $\frac{1}{2}(n_1+n_2)\,\triangle h=\tau_1-\tau_2$ as found by inversion of the refraction formula (columns 2 and 3 of Table XXI for our case). Having the sum and difference the separate values τ_1 and τ_2 are computed. This process presupposes that the suppositions involved in the theory respecting the condition of

* Meterologische Zeitschrift, April Heft, 1881; Separatabdruck aus dem XVI Bande.

the atmosphere, and especially the law of distribution of its temperature, hold for particular cases; comparisons therefore at many places in different climates and at different seasons would be most desirable contributions to our knowledge of hypsometry.

TABLE XXI (*b*).—*Rate of change of temperature with altitude for the stratum of air between Bodega Head and Ross Mountain, California, and comparison of observed and computed temperatures at these stations.*

Hour.	Computed n.	Observed n.	Computed minus observed. Δn	Observed temperature at Bodega Head.	Observed temperature at Ross Mt.	Required correction by theory.	
						Bodega Head.	Ross Mountain
A. M.	°	°	°	° C.	° C.	°	°
7	—.0031	+.0016	—.0047	+ 8.44	+ 7.50	—1.4	+1.4
8	—.0007	+.0036	—.0043	10.17	8.00	—2.4	+0.2
9	+.0034	+.0026	+.0008	11.56	10.00	—3.0	—3.4
10	+.0036	+.0033	+.0003	12.89	10.94	—4.0	—4.2
11	+.0027	+.0021	+.0006	13.22	12.00	—4.5	—4.9
Noon	+.0021	+.0007	+.0014	13.33	12.89	—4.5	—5.3
P. M.							
1	+.0013	—.0001	+.0014	13.44	13.50	—5.1	—5.9
2	+.0005	+.0001	+.0004	12.94	12.89	—5.0	—5.2
3	+.0008	—.0006	+.0014	12.33	12.67	—4.4	—5.2
4	+.0014	+.0005	+.0009	11.94	11.67	—3.8	—4.4
5	—.0011	+.0024	—.0035	+11.50	+10.06	—3.6	—1.6

It is to be regretted that this series comprises only daylight obervations, but apparently the diurnal law in the mean value n for these stations also points to negative values during the hours of the night.

We next observe the largeness of the individual values n_1 and n_2 and the comparative smallness of the mean amount or $\frac{n_1 + n_2}{2}$ in conformity with the small observed values $\frac{T_1 - T_2}{\Delta h}$. The rate of decrease of temperature with increase of altitude is usually taken as 0°.60 C. per 100 meters; the Martinez East and Mount Diablo observations yield only 0°.29 C., though in the diurnal variation the value 0°.62 is reached, in maximo, at 5 p. m.

Table XXII contains the apparent corrections required by the observed temperatures at Martinez East and at Mount Diablo as demanded by theory and depending on a combination of the observed difference of height by spirit-level, of the observed zenith distances, and of the observed atmospheric pressures.

TABLE XXII.—*Comparison of deduced and observed temperatures of the air at the observing stations Martinez East and Mount Diablo.*

Hour.	Observed temperatures.		Required temperatures.		Difference or apparent correction.	
	T_1 Martinez East.	T_2 Mount Diablo.	τ_1	τ_2	$\tau_1 - T_1$	$\tau_2 - T_2$
A. M.	° C.	° C.	°	°	°	°
1	+ 7.86	+ 6.24	+ 9.44	+ 10.56	+ 1.58	+ 4.32
2	7.62	6.26	9.48	10.82	+ 1.86	+ 4.56
3	7.40	6.17	9.02	11.48	+ 1.62	+ 5.31
4	7.21	5.96	9.50	11.30	+ 2.29	+ 5.34
5	7.21	5.80	9.06	10.52	+ 1.85	+ 4.72
6	7.53	6.02	9.07	9.29	+ 1.54	+ 3.27
7	8.78	7.09	8.94	9.16	+ 0.16	+ 2.07
8	9.78	8.43	9.74	8.86	− 0.04	+ 0.43
9	10.80	9.56	10.32	8.76	− 0.48	− 0.80
10	11.91	10.72	11.42	8.84	− 0.49	− 1.88
11	13.25	11.33	12.95	8.71	− 0.30	− 2.62
Noon	14.33	10.80	14.03	8.67	− 0.30	− 2.13
P. M.						
1	15.43	10.70	14.06	7.82	− 1.37	− 2.88
2	16.33	10.42	15.17	8.03	− 1.16	− 2.39
3	17.03	10.16	15.66	8.74	− 1.37	− 1.42
4	16.60	9.75	15.84	9.02	− 0.76	− 0.73
5	15.49	8.58	15.08	8.94	− 0.41	+ 0.36
6	13.81	7.64	13.78	9.64	− 0.03	+ 2.00
7	11.78	6.93	12.72	10.50	+ 0.94	+ 3.57
8	10.79	6.61	12.69	11.13	+ 1.90	+ 4.52
9	10.18	6.44	11.84	11.18	+ 1.66	+ 4.74
10	9.31	6.28	10.84	10.62	+ 1.53	+ 4.34
11	8.70	6.41	9.96	10.52	+ 1.26	+ 4.11
Midn't	8.36	6.37	10.28	10.84	+ 1.92	+ 4.47

These apparent corrections compare favorably in sign and magnitude with similar quantities deduced from observations at stations Kupferkuhle–Brocken ($\triangle h = 970.92$ meters), as cited by Dr. Jordan, and with the results at stations Bodega Head–Ross Mountain, California ($\triangle h = 598.74$ meters.)

The observations made by Assistant G. Davidson at Jackson Butte–Round Top, California, of September and October, 1879, will be presented and discussed as soon as the required spirit-levels have been executed, and it is intended to utilize the results of these researches for the computation of the heights of the trigonometrical stations in this part of California.

In the present paper the mean results only were brought out and submitted to analysis, but should it become desirable to work up the individual observations, and scrutinize the results day by day the meteorological conditions require to be fully known, and for this purpose the following table of the direction and force of the wind and other information relating to the state of the sky have been appended. Some of the leading results are shown graphically on the accompanying plate. [Illustration No. 33.]

TABLE XXIII.—*Observations of the direction and force of the wind and state of the sky at Martinez East, California, March and April 1880.*

Abbreviations used.—Wind: 0, calm; 1, very light; 2, moderate; 3, strong; v, variable; sq, squally. Sky: c, clear; h, haze; s, smoky; f, fog; clds, clouds; cldy, cloudy; r, rain. A duplication of a letter indicates an intensified state.

Hour.	March 21.	March 22.	March 23.	March 26.	March 27.	March 28.	March 29.
A. M.							
1	....	....	W. N. W. 1	....	S. 1	....	....
	....	....	h	....	clds	....	....
2	....	....	W. N. W. 1	....	S. 1	....	....
3	....	N. W. 1	W. 1	....	S. by E. 1	....	....
	....	....	h	....	clds	....	....
4	....	....	W. N. W. 1	....	S. by E. 3	....	....
	....	....	....	....	cldy	....	....
5	....	....	N. W. 2	....	S. by E. 2	....	....
	....	....	f	....	clds	....	....
6	0	W. N. W. 1	N. W. 1	S. W. 1	S. S. E. 3	....	S.
	f	....	clds	cldy	cldy	....	cldy
7	....	....	v. 1	S. W. 1	....	....	S. S. W 1
	....	....	clds	....	....	....	cldy
8	....	....	N. W. 3	S. W. 2	....	....	....
	....	....	clds	h	....	....	....
9	....	W. 2	W. by N. 2	N. W. 2	....	....	S. W. 1
	....	....	cldy	clds	....	....	clds
10	N. N. W. 1	W. 2	W. by N. 2	N. W. 2	....	....	S. W. 1
	h	....	cldy	cldy	....	....	clds
11	W. N. W. 1	W. 2	W. by N. 3	W. 1	....	....	W. N. W. 2
	h	h	cldy	cldy	....	....	clds
Noon	W. N. W. 1	W. 2	W. by N. 2	W. S. W. 1	....	....	W. N. W. 2
	....	....	cldy	cldy	....	....	clds
P. M.							
1	W. N. W. 1	W. N. W. 2	W. by N. 2	S. W. 1	....	W. 2	W. N. W. 2
	c	h s	....	clds	....	c	clds
2	W. N. W. 1	W. N. W. 2	W. by N. 3	S. W. by W. 1	....	W. S. W. 3	W. N. W. 2
	h	h s	clds	cldy	....	clds	clds
3	....	....	....	S. W. 1	....	W. S. W. 3	W. 2
	....	....	....	cldy	....	clds	clds
4	W. 1	W. N. W. 1	N. W. 3	....	....	W. S. W. 3	W. 2
	s	h s	clds	....	....	clds	clds
5	W. 2	W. N. W. 1	N. W. 2	W. S. W. 2	....	W. S. W. 3	W. 2
	s	h s	clds	cldy	....	clds	....
6	W. 2	W. N. W. 1	W. 2	W. S. W. 2	....	....	W. 2
	....	h s	....	clds	....	....	....
7	W. 2	W. N. W. 1	....	S. by E. 1	....	....	....
	s	....	....	....	....	....	....
8	W. 2	....	....	....	....	S. W. 1	W. N. W. 1
	c	....	....	....	....	clds	c
9	....	S. E. 1	W. N. W. 1	S. by E. 1	....	S. W. 1	W. by N. 2
	....	h	clds	clds	....	clds	....
10	....	N. W. 1	S. W. 2	W. 1	....	S. W. 1	N. W. 1
	....	h	....	clds	....	clds	c
11	W. N. W. 2	W. N. W. 2	S. W. 3	S. 1	....	....	N. W. 1
	....	s	sq	clds	....	....	....
Mdn't	W. N. W. 2	W. N. W. 2	S. W. 3	S. 1	....	....	N. W. 1
	....	h	clds	clds	....	....	c

TABLE XXIII.—*Observations of the direction and force of the wind, &c.*—Continued.

Hour.	March 30.	March 31.	April 6.	April 7.	April 8.	April 9.	April 10.
A. M.							
1	N. W. 1	W. by S. 2	....	....	W. 1	N. W. 1	....
	c	cldy	....	....	c	clds	....
2	N. W. 1	W. S. W. 1	....	....	W. 1	N. W. 1	....
	c	clds	....	....	c	cldy	....
3	N. W. 1	S. W. 1	....	....	S. 1	N. W, 1	....
	c	cldy	....	....	c	cldy	....
4	N. W. 1	S. W. 1	....	....	N. 1	N. W. 1	....
	c	cldy	....	....	c	cldy	....
5	N. W. 1	S. 1	....	....	N. 1	N. W. 1	....
	c	r	....	....	c	r	....
6	N. W. 1	S. by E. 1	....	....	N. E. 1	W. S. W. 1	0
	c	cldy	....	....	ff	r	c
7	N. W. 1	S. by E. 1	....	....	....	N. W. 1	N. N. W. 2
	c	cldy	....	....	....	r	clds
8	N. W. 1	S. W. 1	....	....	....	N. W. 1	N. W. 1
	c	cldy	....	....	....	r	clds
9	N. W. 1	N. E. 1	....	....	N. E. 1	N. W. 1	N. W. 1
	c	cldy	....	....	f	rr	clds
10	N. W. 1	N. E. 1	....	....	E. N. E. 1	S. 1	N. W. 1
	c	cldy	....	....	f	rr	clds
11	N. W. 1	N. E. 1	....	W. 1	E. N. E. 1	S. E.	N. W. 1
	c	cldy	....	clds	h	....	clds
Noon	N. 1	N. E. 1	....	N. W. 1	E. N. E. 1	N. E. 1	N. W. 1
	c	cldy	....	clds	h	r	clds
P. M.							
1	N. 1	N. by E. 1	....	W. by N. 1	N. N. E. 1	....	N. W. 1
	....	cldy	....	c	clds	....	clds
2	N. W. 1	N. by E. 1	....	N. W. 1	N. E. 1	....	N. W. 1
	....	r	....	....	clds	....	clds
3	N. W. 1	S. E. 1	....	N. N. W. 1	N. E. 1	....	N. W. 1
	....	r	....	clds	clds	....	clds
4	W. N. W. 2	S. E. 1	....	N. W. 1	N. E. 1	....	W. S. W. 1
	....	cldy	....	clds	clds	....	cldy
5	W. 2	0	....	N. W. 1	N. E. 1	....	W. S. W. 1
	....	cldy	....	clds	clds	....	cldy
6	W. 1	....	....	N. W. 1	0	....	W. S. W. 1
	clds	....	....	clds	clds	....	cldy
7	W. 1	....	W. 1	W. N. W. 1	0	....	W. 1
	clds	....	cldy	cldy	clds	....	clds
8	W. by S. 1	....	W. 2	S. 1	0	....	S. 1
	....	....	cldy	clds	c	....	c
9	W. by S. 2	....	W. 2	N. W. 1	N. W. 1	....	S. W. 1
	clds	....	cldy	clds	c	....	c
10	S. W. 2	....	W. 2	W. 1	N. N. W. 1	....	W. 1
	clds	....	cldy	clds	c	....	c
11	W. 2	....	....	W. 1	N. N. W. 1	....	0
	clds	....	....	clds	....	....	c
Mdn't	W. 1	....	....	W. 1	N. W. by N. 1	....	S. E. 1
	cldy	....	....	clds	cldy	....	clds

TABLE XXIII.—*Observations of the direction and force of the wind, &c.*—Continued.

Hour.	April 11.	April 12.	April 13.	April 17.	April 18.	April 19.	April 23.
A. M.							
1	S. 1	W. by S. 1	W. 2	....	....	S. 1	....
	clds	clds	clds	....	....	h	....
2	S. E. 1	W. by S. 1	W. by N. 1	....	....	S. 1	....
	clds	clds	clds	....	....	clds	....
3	S. E. 1	S. W. 1	W. 1	....	....	S. 1	....
	clds	cldy	clds	....	....	cldy	....
4	S. 1	W. by S. 1	S. W. 1	....	....	S. 1	....
	clds	cldy	clds	....	....	cldy	....
5	W. 1	W. by S. 1	W. 1	....	....	S. S. E. 2	....
	clds	cldy	clds	....	....	clds	....
6	W. 1	S. W. 1	W. 1	....	....	S. S. E. 1	....
	clds	clds	....	....	....	r	....
7	S. W. 1	W. S. W. 1	W. 1	W. N. W. 2	W. N. W. 1	....	....
	clds	clds	....	clds	clds	....	....
8	N. 1	W. N. W. 1	W. 2	W. 2	W. by N. 1	S. S. E. 1	....
	clds	clds	....	clds	....	r	....
9	W. 1	S. W. 2	W. by S. 2	....	W. by N. 1	....	....
	clds	clds	clds	....	clds	....	....
10	N. W. by W. 1	W. S. W. 2	W. 2	....	N. W. 1	....	....
	clds	clds	r	....	....	....	....
11	W. by N. 1	W. S. W. 2	W. N. W. 2	N. W. 2	N. W. 1	... .	....
	clds	clds	r	clds	....	....	....
Noon	W. S. W. 1	W. 3	W. N. W. 2	N. W. 2	N. N. W. 1	....	N. 1
	clds	clds	r	clds	clds	....	clds
P. M.							
1	W. 2	W. S. W. 2	W. 2	W. by S. 3	W. 1	....	N. N. W. 1
	clds	clds	....	r	clds	....	clds
2	W. 2	W. 2	W. 2	W. 3	W. by S. 1	....	N. W. 1
	clds	r	....	r	clds	....	....
3	S. W. 2	W. N. W. 2	W. 2	W. by S. 3	W. by S. 1	....	N. W. 1
	clds	r	....	clds	clds	....	clds
4	S. W. 2	W. S. W. 2	W. 2	W. 3	W. 1	....	N. W. 2
	clds	r	clds	clds	clds	....	....
5	W. S. W. 2	W.	W. 2	....	W. S. W. 1	....	N. W. 1
	clds	....	clds	....	clds	....	....
6	....	W.	W. N. W. 2	....	W. 1	....	W. N. W. 1
	....	....	clds	....	cldy	....	clds
7	W. 2	....	W. S. W. 1	....	W. 1	....	W. N. W. 1
	clds	....	clds	....	clds	....	c
8	W. 2	W. by N. 2	W. 1	....	W. S. W. 1	....	W. N. W. 1
	clds	clds	clds	....	c	....	c
9	W. 2	W. 2	W. by S. 1	....	W. S. W. 1	....	N. W. 1
	clds	clds	clds	....	clds	....	c
10	W. S. W. 1	W. 2	....	....	S. 1	....	W. N. W. 1
	c	c	....	....	....	....	c
11	W. S. W. 1	W. N. W. 2	....	....	S. 1	....	0
	c	clds	....	....	... .	....	c
Mdn't	W. S. W. 1	W. 2	....	....	S. W. 1	....	0
	c	c	....	....	clds	....	c

TABLE XXIII.—*Observations of the direction and force of the wind, &c.*—Continued.

Hour.	April 24.	April 25.	April 26.	April 27.	April 28.	April 29.
A. M.						
1	0	S. 1	S. 1	N. W. 1	N. W. 2	N. W. 1
	c	....	clds	h	f	f
2	0	W. 1	S. W. 1	N. W. 1	N. W. 2	N. W. 1
	c	....	clds	h	f	f
3	N. 1	S. by E. 1	S. 1	0	N. W. 2	N. W. 1
	c	....	clds	h	f	ff
4	W. S. W. 1	W. 1	S. W. 2	0	S. W. 1	N. W. 1
	c	clds	f		f	f
5	0	W. 2	W. S. W. 1	....	0	0
	c	clds	f	f	f	c
6	0	W. 1	W. 1	0	N. W. 1	N. W. 1
	c	f	f	h	f	f
7	0	N. W. 1	W. 1	0	N. N. W. 2	N. W. 1
	c	f	f	h	f	h
8	0	W. 1	W. 1	N. W. 1	N. W. 2	N. W. 1
	c	clds	f	f	f	h
9	N. N. W. 1	W. S. W. 1	N. N. W. 1	N. N. W. 2	N. W. 1	N. W. 1
	....	h	h	f	hh	h
10	W. 1	W. by S. 1	N. W. by N. 1	N. W. 1	N. W. 1	N. W. 1
	....	h	h	h	hh	h
11	N. 1	W. N. W. 1	N. W. 1	N. W. 1	N. W. 1	N. W. 2
	....	....	hh	h	hh	h
Noon	N. W. 1	W. N. W. 1	N. W. 1	N. W. 1	N. W. 1	N. W. 2
	....	h	hh	h	h	h
P. M.						
1	N. W. 1	W. S. W. 1	N. N. W. 1	N. W. 1	0	N. W. 1
	....	clds	clds	h	c	ff
2	N. W. 1	W. by S. 1	N. N. W 1	N. W. 2	N. W. 1	N. W. 2
	....	....	clds	clds	c	cldy
3	W. 1	W. S. W. 2	W. N. W.	N. W. 2	N. W. 1	N. W. 2
	....	....	clds	h h	cc	cldy
4	W. N. W. 1	N. W. 2	W. N. W. 1	N. W. 2	N. W. 1	N. W. 2
	....	....	clds	clds	cc	cldy
5	N. W. 1	W. 1	W. N. W. 2	N. W. 2	....	N. W. 2
	....	....	....	h	....	cldy
6	N. W. 2	W. 1	W. 2	N. W. 2	W. 1	N. W. 2
	....	clds	c	c	cc	cldy
7	N. W. 1	W. 1	W. 1	N. W. by W. 1	N. W. 2	W. 2
	c	....	h	h	c	clds
8	N. W. 1	W. 1	W. 1	N. W. 2	N. W. 2	. W . 1
	c	c	h	c	c	....
9	S. 1	0	N. W. 1	N. W. 2	N. W. 2	....
	c	h	h	c	c	....
10	N. W. 1	S. 1	N. W. 1	N. W. 2	....	....
	c	c	h	c	....	....
11	W. 1	S. 1	N. W. 1	N. W. 2	N. W. 1	....
	c	....	c	c	c	....
Mdn't	S. 1	W. 2	N. W. 1	N. W. 2	N. W. 1	....
	....	....	hh	c	h	....

TABLE XXIV.—*Observations of the direction and force of the wind and state of the sky at Mount Diablo, California, March and April,* 1880.

Abbreviations used.—Wind: 0, calm; 1, very light; 2, moderate; 3, fresh; 4, strong; 5, very strong; 6, gale. Sky: c, clear; h, hazy; m, misty; f, fog; clds, clouds; cldy, cloudy; r, rain; s, sleet; hl, hail; sn, snow. Duplication of letter indicates intensified state.

Hour.	March 21.	March 22.	March 23.	March 26.	March 27.	March 28.	March 29.
A. M.							
1	....	0	....	....	S. W. 2	Martinez	Fog
	....	c	....	....	m	....	....
2	....	....	S. 2	....	....	East	and
	....	....	c	....	....	....	....
3	....	....	....	....	....	until	snow
	....	....	....	....	clds.	....	....
4	....	....	....	....	clds.	after	up
	....	....	....	....	clds.	....	....
5	....	....	....	....	clds.	eleven	to six.
	....	f	....	....	s.	....	....
6	....	....	....	....	Heavy	o'clock	....
	....	f	....	....	....	....	f
7	....	....	....	....	rain	March	....
	....	f	f	....	....	....	....
8	....	....	....	....	wind	twenty	....
	....	....	f	....	....	....	cldy
9	....	....	....	....	and	eighth.	....
	....	c	....	....	....	....	....
10	W. N. W. 2	....	....	....	snow	....	....
	c	....	....	clds and f	....	....	....
11	W. N. W. 2	0	....	....	storm	....	0
	c	c	....	....	....	....	cldy
Noon	0	....	....	....	set	....	S. W. 1
	....	....	....	f	....	....	sn
P. M.							
1	0	0	S. 2	....	in	S. W. 2	W. S. W. 1
	h	c	clds	clds	....	cldy	clds
2	0	....	....	....	which	W. S. W. 2	....
	h	....	f	clds	....	cldy	sn
3	0	....	S. 3	....	lasted	....	S. W. 1
	h	....	f	clds	....	....	cldy
4	0	....	....	....	till	W. S. W. 2	S. W. 1
	h	....	f	....	....	....	cldy
5	N. N. W. 1	S. 1	....	N. W. 3	March	....	....
	....	....	f	cldy	....	f and clds	clds
6	N. W. 2	....	S. 3	....	the	....	N. W. 3
	clds	....	f.	f	....	....	f and clds
7	N. 2	....	S. 3	S. W. 3	twenty-	....	....
	c	....	....	m	....	....	clds
8	....	S. 1	S. 3	....	eighth.	....	W. 1
	....	....	f	f	....	....	clds
9	....	S. 2		....	preventing	....	....
	....	....		....	....	....	clds
10	....	S. 3		S. W. 3	the	....	....
	....	....	Enveloped in	f	....	....	clds
11	....	S. 2	fog clouds	S. W. 3	seeing	....	S. W. 1
	....	....		clds	....	....	f
Mdn't	....	S. 2		....	of	....	....
	....	....		clds	....	....	clds

TABLE XXIV.—*Observations of the direction and force of the wind, &c.*—Continued.

Hour.	March 30.	March 31.	April 6.	April 7.	April 8.	April 9.	April 10.
A. M.							
1	N. W. 2	S. W. 3	....	....	....	S. 2	....
	c	cldy	....	....	....	c	....
2	....	....	....	....	....	....	....
	c	....	....	....	....	....	....
3	3	....	....	....	....	S. 3	....
	....	....	....	....	....	clds	c
4	....	S. W. by W. 3	....	....	....	S. 3	....
	....	cldy and f	....	....	....	r	....
5	....	....	....	....	....	....	....
	....	....	....	....	....	r	....
6	....	....	....	....	....	....	W. by S. 1
	....	....	....	....	f	r	c
7	....	....	....	....	....	....	....
8	0	....	....	....	....	....	....
9	....	....	....	....	....	....	....
	....	....	....	....	....	....	clds
10	....	....	....	....	....	....	....
	....	....	....	....	clds	....	f
11	....	....	....	....	S. S. E. 3	S. 4	....
	....	....	....	....	c	clds	f
Noon	....	....	....	....	....	S. 4	S. to W. 1
	....	....	....	....	....	clds	....
P. M.							
1	0	....	....	W. 1	S. S. E. 1	....	S. W. 2
	....	....	....	f	h	....	hh
2	....	....	....	....	S. 1	....	....
	....	....	....	clds	clds	....	....
3	....	....	....	E. 1	S. 3	....	....
	....	....	....	clds	hh	....	....
4	N. 1	....	....	S. E. 1	....	....	....
	h	....	....	h	....	....	clds
5	N. W. 1	....	....	....	....	Storming	....
	hh	....	....	....	....	....	....
6	W. 1	....	....	....	....	hard	....
	clds	....	....	....	....	....	....
7	S. W. 1	....	....	S. S. E. 1	....	at	S. W. 3
	clds	....	....	cldy	....	....	....
8	S. W. 3	....	W. by N. 1	....	....	dark	S. W. 3
	....	....	c	....	....	....	c
9	S. W. 3	....	....	....	....	on	W. 3
	....	....	....	....	....	....	c
10	S. W. 3	....	....	S. S. E. 2	....	April	....
11	S. W. 3	....	....	....	....	the	....
Midn't	S. W. 3	....	....	S. E. 1	S. 3	ninth.	W. 3

TABLE XXIV.—*Observation of the direction and force of the wind, &c.*—Continued.

Hour.	April 11.	April 12.	April 13.	April 17.	April 18.	April 19.	April 23.
A. M.							
1	N. W. 1	....	Since.	....	....	....	Observations.
	c	clds	....	....	....	....	....
2	....	....	last	....	....	....	have
3	....	....	observation	....	....	....	been
4	0	....	at	....	....	S. W. 2	prevented
	c	f	....	....	....	....	....
5	....	....	2 p. m.	....	....	....	since
	....	f	....	....	....	....	....
6	....	....	yesterday	....	N. W. 2	....	7 a. m
	....	f	....	(*)	clds †	cldy	....
7	N. W. 1	....	Martinez	W. by N	....	....	yesterday
	cldy	....	....	clds ‡	....	....	....
8	....	....	has been	....	....	....	by
9	W. 3	....	shut off	....	....	....	snow and
	c	....	....	....	f	....	....
10	....	....	by fog and	....	....	....	rain
11	N. W. 3	....	by rain	N. W. 1	....	....	storms.
	....	cldy	....	f	....	....	....
Noon	....	....	and	....	....	....	N. E. 2
	....	f	....	sn	....	....	c
P. M.							
1	N. W. 3	....	snow	....	....	....	....
	c	cldy	....	hl. & sn	....	....	....
2	....	....	storms.	....	....	....	....
	....	f	....	clds	....	....	....
3	....	....	W. by S	....	....	....	....
	clds	....	m	....	....	....	....
4	....	....	....	....	....	....	....
	clds	....	f	....	cldy	....	....
5	....	....	....	....	....	....	....
	f	....	clds	....	....	....	....
6	....	....	....	....	....	....	....
	f	....	....	....	....	....	....
7	....	....	....	....	....	....	....
8	....	....	....	....	....	....	....
9	....	....	....	....	....	....	....
10	....	....	....	....	....	....	....
11	....	....	....	....	W. by S. 3	....	N. 3
	f	....	....	....	c	....	c
Mdn't	....	....	....	....	....	....	....
	f	....	....	....	....	....	....

* It has been storming hard since the last observation on the 13th, wind from S. E. to S. W.
† About 5 inches of snow on Mount Diablo.
‡ Snow 4 inches deep, and extends over two-thirds of the way down the mountain.

TABLE XXIV.—*Observations of the direction and force of the wind, &c.*—Continued.

Hour.	April 24.	April 25.	April 26.	April 27.	April 28.	April 29.
A. M.						
1	....	....	....	N. E. 3	N. 3	E. S. E. 1
	....	....	....	hh	h	h
2	....	W. 2	....	....	....	....
	....	f	....	....	h, clds	....
3	N. 6	....	N. W. 2	....	....	....
	....	....	....	....	h, clds	f
4	....	....	....	....	....	....
	....	....	f	....	....	f
5	....	....	N. 2	....	....	N. E. 1
	....	clds	f	....	f	clds
6	....	....	....	....	....	....
	....	clds	f	....	f	h
7	N. 2	....	N. N. E. 2	....	....	....
	c	....	clds	....	f	f
8	....	....	....	N. 3	....	....
	....	f	clds	clds	f	....
9	....	....	....	....	....	....
	....	....	clds	....	....	cldy
10	....	....	....	....	N. E. 1	....
	....	....	clds	....	....	hh
11	....	....	....	....	....	....
	....	....	f	....	....	....
Noon	....	....	....	....	0	....
	....	....	clds	....	hh	....
P. M. 1	....	....	....	0	....	0
2	....	....	....	N. 1	....	....
3	....	....	....	....	....	....
	....	h	hh	h	....	....
4	....	....	....	N. 1	....	....
	....	....	hh	h	....	....
5	....	N. 3	....	....	0	....
	....	hh	hh	h	h	....
6	....	N. 3	....	....	....	....
	h	....	h	h	....	....
7	....	W. N. W. 3	....	N. 3	....	....
	....	....	....	c	....	....
8	....	....	....	....	....	....
9	....	....	....	....	....	....
10	....	....	....	....	0	....
	....	....	....	....	c	....
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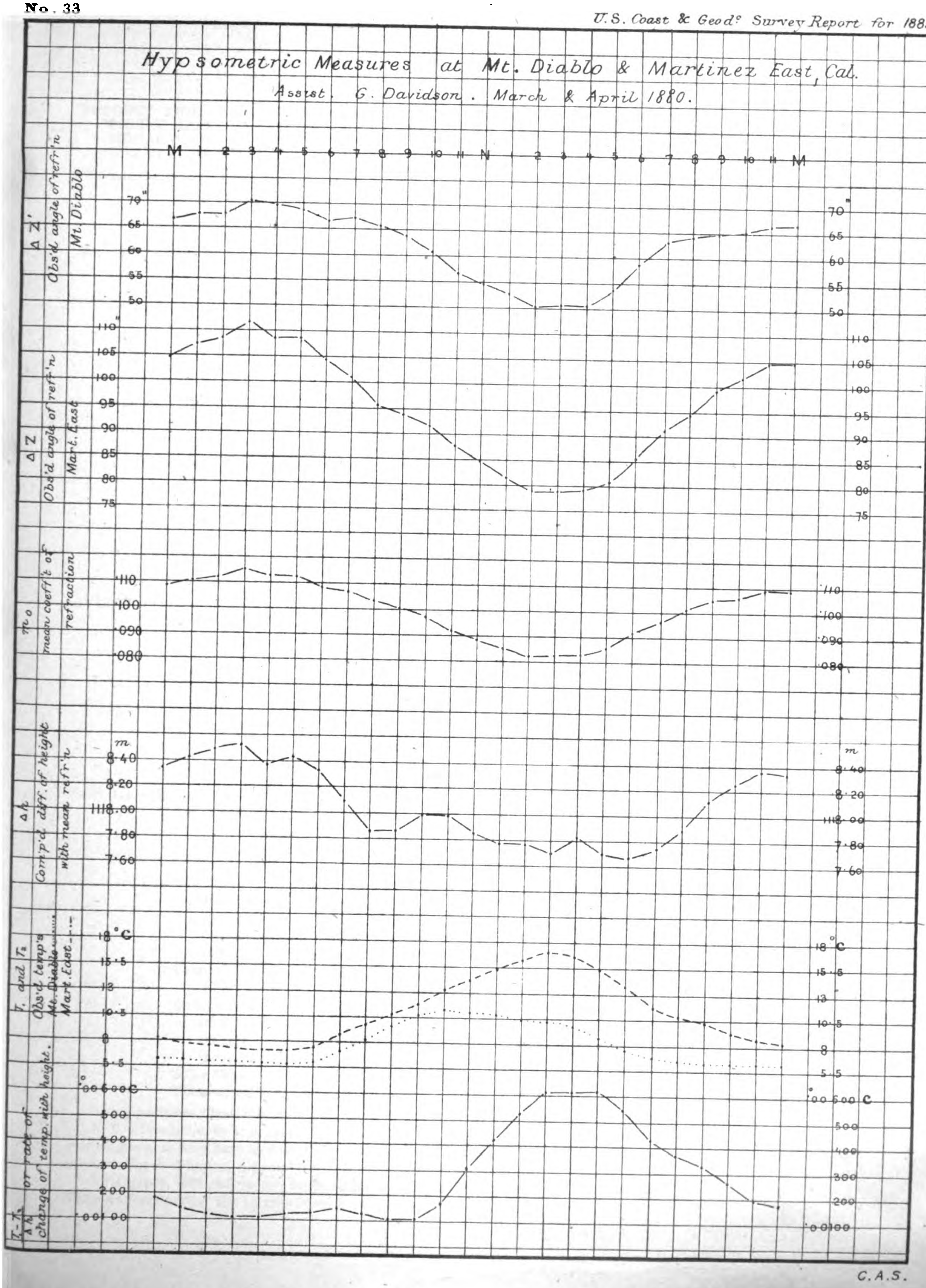
Mdn't	....	....	....	....	S. E. 1	....


Hypsometric Measures at Mt. Diablo & Martinez East, Cal.
Assist. G. Davidson. March & April 1880.
M 1 2 3 4 5 6 7 8 9 10 11 N 1 2 3 4 5 6 7 8 9 10 11 M
Δ Z' Obs'd angle of refr'n Mt. Diablo
Δ Z Obs'd angle of refr'n Mart. East
m₀ mean coeff't of refraction
Δ h Comp'd diff. of height with mean refr'n
T₁ and T₂ Obs'd temp's Mt. Diablo Mart. East
T₁-T₂ / Δh or rate of change of temp. with height.
C.A.S.

APPENDIX No. 13.

ACCOUNT AND RESULTS OF MAGNETIC OBSERVATIONS MADE UNDER THE DIRECTION OF THE UNITED STATES COAST AND GEODETIC SURVEY IN CO-OPERATION WITH THE UNITED STATES SIGNAL OFFICE, AT THE UNITED STATES POLAR STATION OOGLAAMIE, POINT BARROW, ALASKA; LIEUT. P. HENRY RAY, A. S. O., COMMANDING POST.

Reduction and Discussion by CHARLES A. SCHOTT, Assistant Coast and Geodetic Survey.

TABLE OF CONTENTS.

These parts are illustrated by eleven sketches and diagrams and a map of the region about Point Barrow.

N. B.—Discussion to be continued in subsequent parts and so much of the magnetic differential record of 1881-'82 will be given as may here be desirable. The record and computation of the astronomical work, and of the absolute measures for declination, dip, and intensity, 1881-'82-'83, are preserved in manuscript.

This paper, *with full record, inclusive of the term-day observations*, will be printed by the United States Signal Office, to form part of the International Polar Researches.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,
May 6, 1884.

DEAR SIR: Towards the end of March, 1881, Mr. Carlile P. Patterson, then Superintendent of the United States Coast and Geodetic Survey, was invited to aid and co-operate in the researches proposed by the International Polar Commission, which held its second session at Bern, Switzerland, in August, 1880, H. Wild, president. General W. B. Hazen, Chief of the United States Signal Corps, U. S. A., having notified the Commission that the United States would take part in the undertaking, caused two expeditions to be fitted out, one to proceed to Point Barrow, Alaska, the other to Lady Franklin Bay, Grinnell Land. The Coast and Geodetic Survey was to co-operate in the magnetic work which these parties were to execute by furnishing such magnetic and other instruments as were then available, and by instructing three or four observers of the Signal Corps in their use, besides bearing a part of the expense of the first-named expedition, the second expedition having been provided for by special appropriation of Congress.

PART I.—INTRODUCTION.

It was not until near the close of April that these preliminary arrangements were concluded and it was well understood, in consequence of the want of suitable magnetic instruments, and in particular of differential instruments, and owing to the fact that no trained scientific observers were at the time available, that the Coast and Geodetic Survey could not then follow the minute instructions which had been prepared for the guidance of the various expeditions which were to take part in the work of the Commission. In the words of the Superintendent, we were simply to do for terrestrial magnetism the best that was possible at the time. For the first year at Point Barrow, and during the entire absence of the other expedition, the assistance of the Survey was more incidental than fully co-operative, but this condition was considerably improved in the second year at Point Barrow, when we were able to send a set of differential instruments with a newly instructed observer. In the summer of 1883 a special observer was sent in charge of pendulum work, and particularly to verify the magnetic work as well as to redetermine the geographical position and the true meridian or azimuth, but unfortunately he was unable to accomplish anything in consequence of the continued rain, fog, or cloudiness of the sky during the few days he could stay at the place, the state of the ice and the damaged condition of the vessel demanding a speedy embarkation of the whole party.

That under these circumstances the magnetic work should fall somewhat short of the accuracy which the Commission had desired it should possess is not surprising; indeed, the Polar Conference found afterwards that so far as the first year's magnetic work was concerned it appeared to have been undertaken rather prematurely, inasmuch as it could not be supposed that differential instruments of a particular description were ready at hand, nor was there sufficient time to procure them. Disclaiming therefore such close co-operation as would have been desirable but which was impossible under the circumstances, the records and results herewith presented are the outcome of faithful labor, and are believed to be an acceptable contribution to our knowledge of magnetism in high latitudes, and it is thought that in the second year, at least, these records will prove to be a valuable part of the material accumulated by the several expeditions.

Later on, in full co-operation with the work undertaken by the International Polar Commission, the Coast and Geodetic Survey established at Los Angeles, Cal., a magnetic observatory and equipped it with a set of Adie's self-recording magnetometers of the Kew pattern. In the spring of 1882 the adobe building had been constructed by Assistant J. S. Lawson, and in July following the instruments were mounted and the photographic process was arranged by Mr. W. Suess, mechanician Coast and Geodetic Survey. The observatory was then permanently turned over to the charge of Mr. Marcus Baker, Coast and Geodetic Survey, under whose direction the absolute and differential measures have been made uninterruptedly from about the end of September, 1882, to the present time, and it is the intention to continue the work for some years.

In May, 1881, Mr. J. B. Baylor, and, in June following, Mr. M. Baker, of the Geodetic and Coast Survey, were detailed to instruct, at Washington, Sergeants E. Israel, J. Cassidy, J. Murdoch, and M. Smith, Signal Corps, United States Army, in the use of the sextant and the

altazimuth for the determination of time, latitude, longitude, and azimuth, and in the requisite computations; they were likewise instructed in the use of those magnetic instruments which they were to take with them. Mr. A. C. Dark was instructed at San Francisco in astronomical observations by Sub-assistant J. F. Pratt, Coast and Geodetic Survey. With the exception of Sergeant Israel, who proceeded to Lady Franklin Bay, the above-named observers formed part of the *personnel* of the Point Barrow party. These observers made the best use of the short time available for their instruction.

In May, 1882, J. Palmarts and Sergt. J. E. Maxfield, Signal Corps, United States Army, received instructions from Mr. Baker in the use of the sextant and the theodolite, and in June they practiced under Assistant Eimbeck, Coast and Geodetic Survey, with the Brooke differential instruments, which left the office for Point Barrow June 14, 1882.

The following instructions to the parties were drawn up (June 9, 1881) by the writer, under direction of Superintendent C. P. Patterson:

"INSTRUCTIONS AND NOTES FOR THE GUIDANCE OF THE OBSERVERS TO BE STATIONED AT POINT BARROW, ALASKA, AND AT LADY FRANKLIN BAY, NORTH OF SMITH SOUND, ARCTIC OCEAN.

"As soon as the quarters of the expedition have been fixed upon, a magnetic house will be erected, in which the regular magnetic observations, as described below, will be made; other observations will be made when on boat or sledge trips.

"*Instruments.*—For the use of the magnetic observatory there will be provided a magnetometer for absolute and differential declination and for horizontal magnetic intensity, to be permanently mounted on a stone pier. In connection with this instrument a meridian or azimuth mark will be established a short distance off the observatory and visible from it through an opening in its wall. The astronomical bearing of this mark will be carefully determined by means of an altazimuth instrument and solar observations. In the same house, but on a separate pier, will be mounted a Kew dip circle, and in the case of Point Barrow a third instrument, a bifilar magnetometer, will also be permanently mounted on its pier. At Point Barrow the magnetometer (or unifilar) and the bifilar instruments will be mounted in the magnetic meridian and at a distance apart not less than 12 feet, and the dip circle will be mounted equidistant from these instruments, forming an equilateral triangle. At Lady Franklin Bay the two instruments will be mounted in the plane of the magnetic prime vertical and not less than 12 feet apart. No iron is to be used in the construction of these buildings, and they should not be nearer than 50 yards to any other building, or double that distance to any large mass of iron. Special reading lamps (of copper) must be provided for use with the instruments, and they must be tested to make sure that they do not affect the position of the magnets. The use of candles, stuck in wooden blocks, is preferable to lamps.

"When on boat or sledge journeys the party will carry a chronometer, a small altazimuth instrument, with circles of about 3 inches diameter (as constructed by Fauth & Co., of Washington, or Casella, of London), provided with a magnetic needle or compass mounted over its vertical axis, and a dip circle.

"*Observations at the permanent station.*—Hourly observations will be made for declination and diurnal variation with the magnetometer on three consecutive days about the middle of each month; besides these observations, extending over seventy-two hours, there will be made at any convenient intermediate time *each* day (of the three) one set of deflections, followed immediately by a set of oscillations for the determination of the horizontal intensity. At Point Barrow the bifilar will be read immediately after the unifilar. There will also be made at any intermediate time *each* day (of the three) a set of dip observations. In connection with the declination, the mark will be read once each day (unless the instrument should accidentally be disturbed), but it suffices to determine the magnetic axis of the declination magnet on one of three days. The instrumental constants of the magnetometer will be determined before leaving Washington, and the observer will use the Coast and Geodetic Survey magnetic blank forms for their records, or in case no special forms are provided they will use small (octavo) note-books; they will also compute,

as soon as the observations are completed each month, the magnetic mean declination, diurnal range, and turning hours, also the horizontal force in absolute measure (English units) and the dip, tabulating the results for each day.

"Extra observations on other than the three days about the middle of each month will be made during all occurrences of auroral displays, but as they are likely to be very numerous at Point Barrow, observers there may confine their extra observations to the more conspicuous displays only. On these occasions the declinometer (and the bifilar) at Point Barrow will be read every ten minutes, or oftener or less often, as the state of the needle may appear to demand, the object being to ascertain the relation and establish a connection between the appearance of the aurora and the motion of the magnetic needle.

"When landing, on a boat journey or during a sledge journey, at suitable stations (not less than 10 or 15 miles apart), the time, latitude, and azimuth will be determined by the altazimuth instrument, and the declination by the same instrument (the hour and minute of the observation is to be noted in order that the diurnal variation may be allowed for); the dip will also be observed, and, in case time is pressing, reversal of circle, reversal of face of needle, and reversal of polarity of needle may be dispensed with, but the needed corrections to the result from the single position of the instrument must be ascertained at the permanent station. Observations of deflections with magnetic needle (and with weights) will be made with the dip circle as arranged for relative and absolute total force, the data for the latter to be supplied at the permanent station.

"It is highly desirable, especially in the case of the Lady Franklin Bay party, that all stations within reach and formerly occupied by other parties for magnetic purposes be revisited in order to furnish material from which to deduce the secular change during the interval; besides, all opportunities should be taken when landing on the way up to secure observations for declination, dip, and intensity; the latter best by oscillations of the intensity magnet. The winter quarters of the late English expedition should be connected magnetically with the present quarters.

"*All magnetic observations will be made on Göttingen time, as provided for by the Hamburg Conference.**

"All magnetic work will be kept strictly in conformity with "Notes on measurements of terrestrial magnetism," United States Coast Survey, Washington, D. C., 1877,† and other records in connection therewith should be equally clear and complete, and all computations should be made by the observer in separate books. Duplicates of all records will be made, compared with the original, and the latter returned annually,‡ if practicable, to the Superintendent of the Coast and Geodetic Survey, Washington, D. C. The observers should also provide themselves with copies of the 'Admiralty Manual of Scientific Enquiry,' the 'Arctic Manual and Instructions, 1875,' and 'Auroræ, their Character and Spectra, by J. R. Capron, 1880;' also with 'Terrestrial and Cosmical Magnetism, by E. Walker, 1866,' and any other work they may require for their information."

Besides the above paper, which is printed pages 12–14 in "Instructions No. 72, War Department, Office of the Chief Signal Officer, Washington, D. C., June 17, 1881," the parties received additional instructions, headed "(2) Obligatory observations in the domain of terrestrial magnetism," and "(3) Elective observations," contained in the same order. Among these optional observations are mentioned observations of tides and of earth currents; for both of these phenomena returns were made.

The Point Barrow party was also provided with a plan of the magnetic house, and received the following note respecting the adjustment of the bifilar magnetometer, which had been hastily constructed from some remains of an older instrument.

"*The portable bifilar magnetometer.*—This instrument was reconstructed from such parts as could be found from an old instrument. A collimator magnet was provided, also a new bifilar suspension, adjustable by means of a right and left handed screw in the place of a disk, as originally supplied; the projecting arms, indicating that the instrument had been arranged for an induction inclinometer, were removed.

* This sentence I find added to original report.

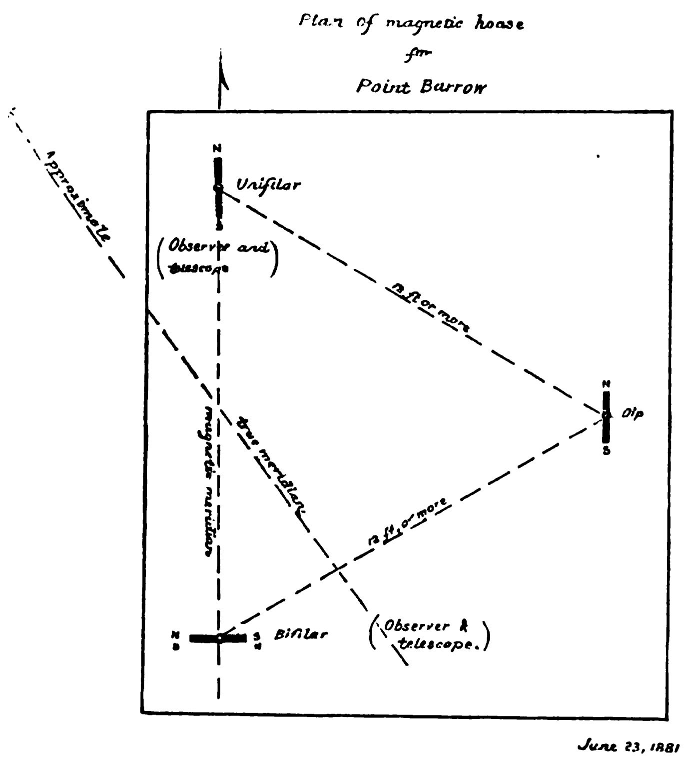
† A new edition, the third, has since appeared in Appendix No. 8, Coast and Geodetic Survey Report for 1881.

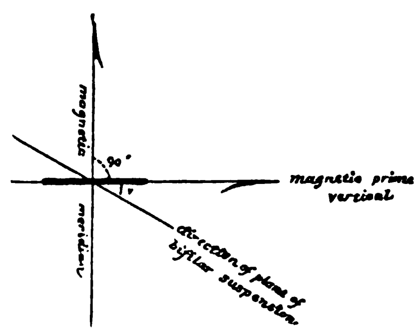
‡ It was then supposed that the parties would remain out for three years.

"It is to be used differentially, or for variations only of the horizontal component of the magnetic force. The instrument is to be adjusted with the axis of the collimator magnet in the magnetic prime-vertical, and the variations of the horizontal force are observed by readings of the scale.

"If H = horizontal magnetic force, $\triangle$H=variation of the same, v=angle of twist in the bifilar suspension (usually between 40° and 70°), $\triangle v$= variation of this angle (expressed in parts of radius), then

$$\frac{\triangle H}{H} = \cot v \triangle v$$





"If n_0= reading of the scale of any fixed part—say of the magnetic axis of the collimator, n= any reading at another time, a=value of one division of the scale in parts of radius (or angular value in minutes times .000291) then

$$\triangle v=(n-n_0)\ a$$

"To correct for changes in the value of $\frac{\triangle H}{H}$ for change of temperature of magnet, let q= change of magnetic moment of magnet corresponding to a change of 1° Fah., we have then the correction $q\ (t-t_0)$ where t_0=normal temperature adopted and t=any other temperature. The value of q may be found by a series of observations of oscillations at high and low temperatures, the magnet being suspended as in the unifilar magnetometer. Putting $k=a \cot v$ we have

$$\frac{\triangle H}{H}=k\ (n-n_0)+q\ (t-t_0)$$

"The value of k may be about .00025 and it should be so arranged, by varying the distance of the threads that the least integer reading of the scale should indicate about $\frac{1}{1000}$ to $\frac{1}{10000}$ part of the horizontal force. The observed variation in the horizontal component of the magnetic force will be true only in case the magnetic moment of the suspended magnet remains unchanged during the time of observations, but as every magnet gradually loses magnetism a further correction for loss of magnetic moment is needed; this may be determined by comparing differences of values

of horizontal force as determined by means of the unifilar magnetometer at certain times (and after long intervals) with a series of corresponding readings of the differential instrument. The magnet being an old one, it seems best to examine and readjust the bifilar at the end of each year or sooner in case of necessity.

"The north end of the magnet may be turned either to the right or left of the meridian, but it will be desirable to choose that side which will make *increasing* horizontal force correspond to *increasing* scale readings.

"The principal adjustments of the instrument may be summed up as follows:

"Level; suspend magnet as unifilar; focus telescope; place scale horizontal and adjust light for distinct vision; take torsion out of suspension; put plane of detorsion in magnetic meridian; determine axis of collimator; determine scale value or value of one division in minutes of arc; point on axis and note corresponding scale reading of magnetic meridian; take off unifilar and substitute bifilar tube; place plane of bifilar suspension in magnetic meridian; point on axis and read torsion circle; test this by turning telescope 180° in azimuth and bringing the magnet in the reversed position, north end to the south, and read torsion scale; if it reads as before the plane of threads was truly in the magnetic meridian; repeat adjustment if necessary; turn telescope 90° or into the magnetic prime-vertical, and turn in the *same direction* the torsion circle until the axis of the collimator appears pointed in telescope; read the torsion circle, it will be $90° + v$ from the meridian value; compute the value of k and alter the distance of threads by turning the screw until a satisfactory value for k is found.

"The observers will remember that at Point Barrow the horizontal force is about one-half of what it is at Washington. They may also consult Lloyd's Treatise on Magnetism (London, 1874)."

With reference to co-operation with the Polar Commission during the *second* year of occupation of the Point Barrow station directions were given by you, May 23, 1882, to prepare the old Brooke magnetographs for immediate service. These instruments had been used for many years, first at Key West, Fla.,* and lately at Madison, Wis., and required thorough overhauling; moreover, photographic registration being out of the question in the Polar regions, they were changed and remounted according to a plan devised by me for direct eye-observations. By extra exertion, with the assistance of Fauth & Co., instrument makers, and W. Suess, mechanician, this was expeditiously done, and the instruments left Washington June 14, 1882.

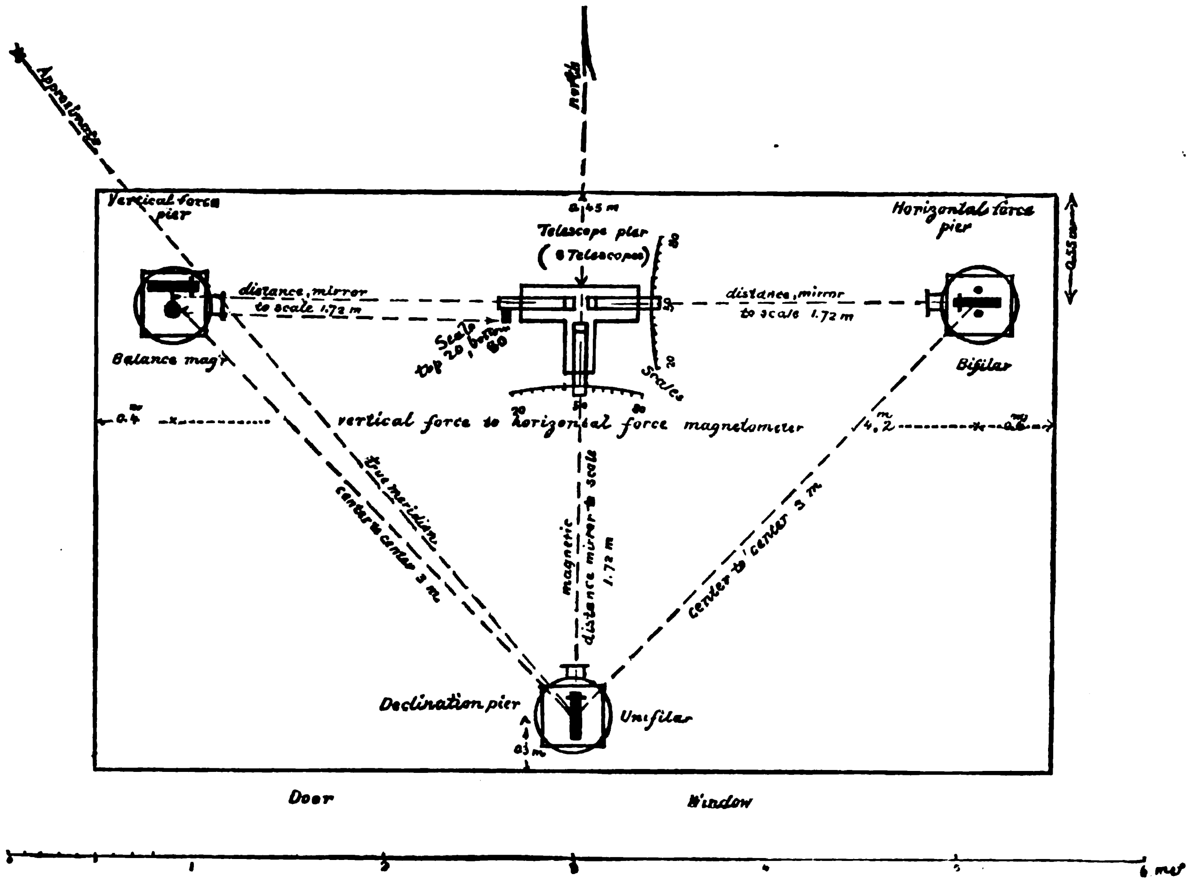
The following memorandum was handed to the relief party before starting for Point Barrow:

"MAY 26, 1882.

"The magnetic instruments intended for Point Barrow will be the modified Brooke magnetometers, viz: declinometer, bifilar or horizontal force magnetometer, and Lloyd's balance or vertical force magnetometer, to be relatively disposed of in a building, as shown in the accompanying diagram.

"The size of the observatory was to be 3 by 5 meters, or about 10 feet by 16½ feet inside, and 6½ to 7½ feet high; size of the brick piers, 0.3 meter square and about 1 meter high; cross-section of telescope pier 0.15 meter by 0.6 long, and of the same height as the instrument piers; the brass cylindrical vessels in the axis of which the magnets are suspended, except the knife-edge of the Lloyd balance which passes through the center, are each of 40 centimeters diameter. This new observatory should be distant from the older one at least 8 meters."

* For a description see Coast Survey Report for 1860, Appendix No. 26, or the original paper in Phil. Trans. Roy. Soc., 1847, Part 1, "On the automatic registration of magnetometers, etc., by photography. By Charles Brooke. June, 1846."



The following notes were prepared for the guidance of the party May 31, 1882:

"NOTES ON THE MOUNTING, THE ADJUSTMENT, AND THE DETERMINATION OF INSTRUMENTAL CONSTANTS OF THE BROOKE DIFFERENTIAL MAGNETOMETERS.

1. THE DECLINOMETER OR UNIFILAR MAGNETOMETER.

"Take out the torsion of the suspension skein or wire, suspending alternately magnet and weight, until the telescope readings are the same; adjust fixed mirror to read 50 of scale, which is to be recorded as 500; adjust movable mirror to read the same for average position between daily extremes; note reading t of torsion circle. Measure torsion of suspension by turning off β degrees to right and to left, and reading the scale (through telescope); turn torsion circle back to reading t.

Let l = length of a division of scale,

r = radius or distance from face of scale to surface of mirror (if of glass silvered on back, two-thirds of the thickness of the glass must be added), then the angular value of one division of scale,

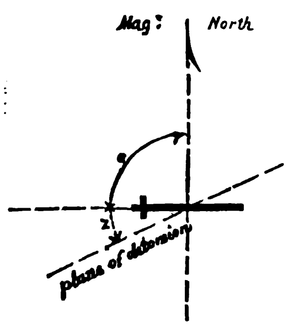
$$a = 3437'.75 \frac{l}{2r}$$

"For the magnetometers the value of l is uniformly 1 millimeter, and the angular value $a = 1'$, the radius r being $= 1.719$ meters, which has to be carefully measured off for each instrument. To determine the torsion coefficient $\frac{h}{f}$ let α = angle through which the magnet was deflected, and β = angle through which the torsion circle had been turned, then $\frac{h}{f} = \frac{\alpha}{\beta - \alpha}$; hence scale value $a\left(1 + \frac{h}{f}\right)$ expressed in minutes of arc. Increasing numbers of scale should correspond

to a motion of the *north* end of the magnet to the *east*. The scale is numbered from 20 to 80 (which numbers are to be read 200 and 800), and thus has a range of 5° on either side of the normal position. Two spare scales, divided on white bristol-board, about 15 centimeters long (giving additional extent of 2½°), should be made, and in case of necessity fastened to the ends of the reading scale. The vertical cross-thread of the telescope *is to be kept* on the 500 mark as reflected from the fixed mirror,* a remark which applies to each of the instruments. The dividing line or narrow space between the fixed and movable mirrors is in the plane of the optical axis of the telescope. The instrument is placed under a zinc cover.

2. The horizontal force or bifilar magnetometer.

"Put plane of detorsion in the magnetic meridian, turn torsion circle with weight suspended approximately in plane of meridian, and read circle. Remove weight, suspend magnet, and again read circle. If the same as before, the plane of detorsion is in the magnetic meridian; if not, repeat the process until the result is satisfactory. It is recommended to mark out in the observatory the directions of the magnetic meridian and of the magnetic prime-vertical by threads or fine strings stretched from wall to wall; these threads would also aid in the setting of the piers. Let m^0=reading of torsion circle for plane of detortion in the meridian; suspend weight and turn torsion circle to $90°+m^0$, turn movable mirror until the middle line or 50 of the scale is bisected, in which position of the telescope the fixed mirror will reflect division 50 (to be read and recorded as before, 500). Suspend magnet in place of the weight, turn torsion to $m_{,}^{0}$, until middle line of scale is again bisected, then $m_{,}^{0}-(90°+m^0)=z$ (see annexed diagram, where $u=90°$). Let H=horizontal component of the earth's magnetic force, m=magnetic moment of magnet, W=weight of magnet and appendages (compensation bar, mirror, stirrup, and part of suspension), 2 a and 2 b the distances of the threads *above* and *below* and l=length of suspension, then



$$\frac{\mathrm{W}ab}{l}\sin z=\mathrm{H}\,m$$

now let H and z vary by δ H and δz and the ratio $\frac{\delta \mathrm{H}}{\mathrm{H}}$ or the variation of the horizontal force expressed in parts of the force is given by the relation

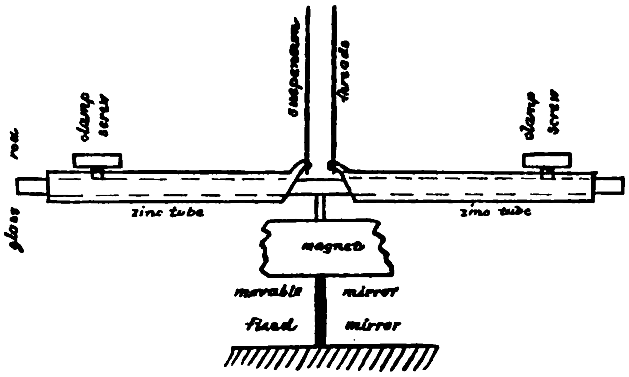
$$\frac{\delta \mathrm{H}}{\mathrm{H}}=\cot z\,\delta z$$

"Suppose the scale division to be 1 millimeter, and the distance of the scale and mirror$=r$ millimeter, then $\delta z=\frac{1}{2r}$. Now, putting for δz its equivalent $a\,(n-n_0)$ where a=value of one division of scale in terms of radius and $n-n_0$=the difference of any two scale readings, and making $k=a\cot z$, the ratio $\frac{\delta \mathrm{H}}{\mathrm{H}}$ becomes $k\,(n-n_0)$. A second method for determining the scale value is as follows: Let $w=\frac{\mathrm{W}}{100}$ or let it be equal to any other convenient fraction of W, and add w to the suspended magnet, then the difference of the two readings of the scale, that is, before and after the small weight was added, or for weight W and for weight W$+w$ will correspond to $\frac{1}{100}$ of the horizontal force. To give the instrument any desired sensitiveness compute the angle of deflection z corresponding to it, and set the torsion circle accordingly; then by means of the upper suspension screw (with its two sets of opposing screw-threads) the suspension-threads are to be brought to that distance which will bring the middle of the scale (50) on the vertical thread of the telescope.

* An important addition to the Brooke instruments, as insuring the stability or fixity of the direction of the zero point of the scale; the idea was taken from the later Adie magnetograph. The circular windows of the three magnetometers were of French plate-glass. By trial, on February 14, 1884, I find that the transmitted rays for the *extreme* scale ends suffered but slight refraction by turning the glass in its own plane; the deviation changed from 0 to 5 divisions in maximo.

Using the second method a weight has to be provided corresponding to the desired sensitiveness and the suspension threads must be regulated in order that the additional weight may produce a change of a certain number of divisions of scale when it is added and taken off.

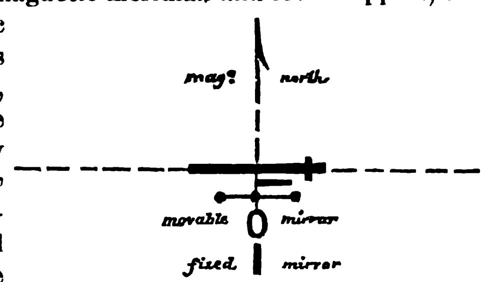
"The instrument is provided with a mechanical compensation for changes of temperature; in view of the extreme low temperatures which are likely to be experienced at Point Barrow, however, and under the present circumstances it will be better to deduce the corrections for any outstanding amount, not compensated, differentially from the observations of the horizontal force themselves, than to attempt a complete mechanical compensation. The latter operates as follows:



Referring to accompanying figure, suppose the temperature increases, the effective force of the magnet will diminish, the differential expansion of glass and zinc (which materials form the compensation) will push the *zinc end in*, which brings the suspension threads closer together and thus diminishes the torsion force, balancing H in the same ratio as H itself diminishes. Increasing scale readings should correspond to increasing horizontal magnetic force or to a movement of the *north end* of the magnet toward the north. The narrow space dividing the fixed from the movable mirror is in the plane of the optical axis of the telescope. The instrument is placed under a zinc cover.

3. The vertical force or balance magnetometer.

"Put the knife-edge supporting the magnet in the magnetic meridian and level support, the magnet will then be free to oscillate in the magnetic prime-vertical; balance the magnet and its appendages (mirror, knife-edge, balancing weights, compensation bar, etc.) horizontally by means of two weights on opposite sides of the knife-edge, next bring the center of gravity of the system to that particular position *close to* and *below* the knife-edge, which corresponds to the desired sensitiveness; this is done by raising or lowering the central ball or weight. Set the mirror so that the middle of the scale (50) is reflected on the thread of the telescope when the magnet is level; at the same time this center division must remain bisected as seen in the fixed mirror.



Let V = the vertical component of the earth's force,
d = the horizontal distance of center of gravity of the system from the plane of support passing through the knife-edge,
W = weight of magnet and appendages,
m = the magnetic moment of magnet,

then $$V\,m = W\,d.$$

"Now suppose the magnet inclined through the small angle ψ and let h = distance of center of gravity of the system below plane of knife-edge, then

$$\frac{\delta V}{V}=\frac{h}{d}\psi$$

"To determine the ratio $\frac{h}{d}$ we oscillate the magnet and appendages in its vertical plane and let T = time of an oscillation when in that position; we then take the magnet off its support and suspend it (with its appendages) by a single thread (determining torsion and allowing for it) as in the case of a free declination magnet, observing that the sides which were vertical when on its bearings will now be horizontal. The moment of inertia will be the same as before. Let $T_{\prime}$ = the time of a horizontal oscillation, then

$$\frac{\delta V}{V}=\frac{T_{\prime}^2}{T^2}\cot \text{dip.}\,\psi \quad =\frac{T_{\prime}^2}{T^2}\psi\cot\theta$$

where $\theta =$ dip. For one linear unit of scale and r units of distance to mirror the value of $\psi = \frac{1}{2r}$. The dip is to be determined by means of the dip circle. For a particular scale value, T, having been determined, we alter the position of the center of gravity by the adjusting screw, until by trial the desired value of T is produced. The scale value may also be ascertained by means of deflections, the magnet being first in a horizontal and next in a vertical position (see page 65 of second part of bulletin, St. Petersburg, 1882).*

"The temperature compensation originally with the Brooke balancing magnetometer consisted of a glass thermometer tube filled with mercury; this has been removed, and a brass arm was substituted as in the Adie instrument. The compensation operates as follows: Suppose the temperature is rising, the magnetic energy of the horizontal magnet will diminish and gravity will consequently pull the south or unmarked end of the magnet down and thus elevate the marked end, but this is counteracted and the balance restored by the expansion of the brass arm which is directed to or on the same side as the marked end; the diminution of magnetic moment is thus counteracted by the increased leverage of the extended brass arm.

"Increasing scale readings should correspond to increasing vertical magnetic force or to a movement of the *north end* of the magnet *downwards*. The instrument is placed under cover of a thick plate-glass.

"Referring to the diagram of the magnetic observatory containing the modified Brooke differential or variation instruments, it will be seen that the north seeking or marked ends of the magnets turn all to the inside or toward the telescope pier. The directions in which the scale numbers increase are also there indicated.

"Time being wanting for an accurate mechanical compensation of the force magnetometers, it is the intention that only the greater part of the change should be so compensated and corrections applied for the remainder; for this purpose thermometers are inserted, which are to be read in connection with the scales. The data for outstanding temperature correction will be had from the ordinary hourly observations."

The Point Barrow party was also put in possession of the resolutions adopted at the third session of the International Polar Conference, held at St. Petersburg, August, 1881. From this publication the following notes were taken:

The differential magnetic observations for changes of declination, horizontal and vertical components of the earth's magnetic force are to be made *hourly* and continuously, commencing as soon as possible on or after August 1, 1882, and closing as late as practicable before or on September 1, 1883.

These *hourly observations* may be made either with reference to *local* time or with reference to any other meridian. [The full hours of *local* mean time are recommended, and the instruments are to be read in the order, bifilar one and one-half minutes before and after, unifilar one minute before and one minute after, and balance magnetometer one-half minute before and one minute after each full hour.]

Term-day observations.—Term days are the 1st and 15th of *each* month (excepting January 1, when January 2 will be taken). The differential instruments on term days are observed every five minutes throughout the twenty-four hours, and strictly according to *Göttingen mean civil time*, beginning with $0^h\ 0^m$ (or midnight at Göttingen). The three instruments will be read as rapidly as possible, one after another, in the order given above, the declinometer being read at the exact full fifth minute.

Additional observations on term days during *one* hour, specified as below. Declination observations will be made every twenty seconds, beginning with the full hour and minute of Göttingen mean civil time.

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* If $\varepsilon =$ angle which the line joining the centers of gravity and of motion makes with the axis of the magnet, we have $\tan\varepsilon \tan\theta = \frac{T_{\prime}^2}{T^2}$; also $\frac{V}{H} = \tan\theta$, and since in our case $a = 90°$, formula (3) of page 63 changes to

$$\delta V = H\ \frac{T_{\prime}^2}{T^2}\,\psi\ ;\ \text{hence}\ \frac{\delta V}{V} = \frac{T_{\prime}^2}{T^2}\,\psi \cot\theta$$

as above.

1882—August	1.	Noon to 1 p. m.	1883—February	15.	1 a. m. to 2 a. m.
	15.	1 p. m. to 2 p. m.	March	1.	2 a. m. to 3 a. m.
September	1.	2 p. m. to 3 p. m.		15.	3 a. m. to 4 a. m.
	15.	3 p. m. to 4 p. m.	April	1.	4 a. m. to 5 a. m.
October	1.	4 p. m. to 5 p. m.		15.	5 a. m. to 6 a. m.
	15.	5 p. m. to 6 p. m.	May	1.	6 a. m. to 7 a. m.
November	1.	6 p. m. to 7 p. m.		15.	7 a. m. to 8 a. m.
	15.	7 p. m. to 8 p. m.	June	1.	8 a. m. to 9 a. m.
December	1.	8 p. m. to 9 p. m.		15.	9 a. m. to 10 a. m.
	15.	9 p. m. to 10 p. m.	July	1.	10 a. m. to 11 a. m.
1883—January	2.	10 p. m. to 11 p. m.		15.	11 a. m. to noon.
	15.	11 p. m. to midnight.	August	1.	Noon to 1 p. m.
February	1.	Midnight to 1 a. m.		15.	1 p. m. to 2 p. m.

If three observers are available all three instruments will be observed.

Absolute magnetic measures of declination, dip, and intensity.—Observations are to be made as often as necessary to furnish the absolute values needed for the differential measures. [Unless some change is suspected in the latter it will suffice to observe for absolute values the declination, the dip, and horizontal intensity (oscillations and deflections) on the day *before each* term day; declination observations will then be made about 8 a. m. and 1 p. m., local time, and for these and the intermediate hours the corresponding readings of the scales of the differential and absolute instruments will be given; observations for dip and intensity may be made at any convenient time of the day.]

Tests are to be made for possible local deflection before selecting the position for the absolute instruments.

Scale values of differential instruments.—The unifilar or declinometer should have a sensitiveness such that 1 millimeter on the scale will correspond to a variation in declination (D) equal to 1′, hence δ D $=1'$. For the bifilar or horizontal force magnetometer, at a place where the dip is θ, one millimeter of its scale will be made to correspond to a variation of the horizontal component (H) of the magnetic force $=0.001 \cos\theta$, hence δ H $= .001 \cos\theta$ expressed in the metric units of the force mm., mg., s. For the vertical force or the balance magnetometer 1 millimeter of the scale will be made to correspond to a variation of the vertical component (V) of the force $=0.001$, hence δ V $=.001$ in the same units as above.*

For absolute measures the Point Barrow party had Coast and Geodetic Survey magnetometer No. 11 and the Lady Franklin Bay party magnetometer No. 12, both new instruments made by Fauth & Co., of Washington; Kew dip circle No. 23 was taken to the former place and Kew dip circle No. 19 to the latter, both instruments the property of the Coast and Geodetic Survey. The magnetometers are described and figured (plate No. 36) in Coast and Geodetic Survey Report for 1881, Appendix No. 8. The Kew dip and intensity circles with needles 9 centimeters in length are well known.

GEOGRAPHICAL POSITION OF OOGLAAMIE STATION, ALASKA.

The two United States Polar expeditions which had been organized under the orders of W. B. Hazen, Brigadier and Brevet Major General, U. S. A., and Chief Signal Officer, left for their respective destinations early in the summer of 1881, the one for Alaska, in command of P. H. Ray, Lieutenant, U. S. A., the other for Lady Franklin Bay, in command of A. W. Greely, Lieutenant, U. S. A.

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* Supposing, for the sake of illustration, that at Point Barrow $H=0.95$ (in mm., mg., s. units) and $\theta=81\frac{1}{2}°$, then $\cos\theta=.1478$ and $\delta H=.0001478=\frac{1}{6766}$ nearly. From $\cot z=\frac{\delta H}{H \text{ arc } 1'}$ we have $\log \cot z=9.72822$, hence $z=61° 52'$, and the whole angle to be turned off would be $90°+z=151° 52'$. For the vertical force instrument we have from $V=H\tan\theta$, $V=6.3565$; also total force $F=H\sec\theta=6.4272$ and for $\delta V=.001$ (metric units), $\frac{\delta V}{V}=.0001573$. The angular value of one division of each of the scales$=1'$.

Lieutenant Ray's party sailed from San Francisco in the Golden Fleece July 18, and arriv Ooglaamie, near Point Barrow, September 8. The meteorological and magnetic station was established near the small Esquimaux settlement of that name,* about 17 kilometers, or $10\frac{1}{2}$ statute miles, from Point Barrow and to the southward and westward of it, about 150 meters from the coast of the Arctic Ocean and at an elevation of about 5 meters above its level.

The geographical position of the station as derived from dead reckoning on board the Golden Fleece is given by Lieutenant Ray,† as follows: latitude 71° 17′ 50″, longitude 156° 23′ 45″ west of Greenwich. The astronomical observations at Ooglaamie for position and direction of meridian were made by A. C. Dark, and are contained in Appendix I, but are not submitted with this report. Observations found defective or unreliable from whatever cause have been omitted in this appendix. The latitude here adopted results from two sets of observations; one, of a series of double altitudes of the sun on April 28, 1882, the other, of two sets of single altitudes of the sun about upper and at lower culmination on June 24, 1882. The first value, from sextant observations, has been given the weight 4, and the second value, from theodolite observations, the weight 1; the resulting latitude becomes $\varphi=71^\circ\ 17'.7$ with an estimated probable error of $\pm 0'.3$. According to British Admiralty Chart 2164 the position of Plover Point, where the English relief expedition under Commander R. Maguire, R. N., was stationed in 1852–'3–'4, is in latitude 71° 21′ 25″ and in longitude 156° 16′ 06″ west of Greenwich. Following the trend of the coast between the cemetery and the summer camp down to Ooglaamie and converting the linear measures of the chart into difference of latitude $\triangle\varphi$ and difference of longitude $\triangle\lambda$ we find for the latitude of Ooglaamie station $71^\circ\ 21'.4-3'.5=71^\circ\ 17'.9$, and for the longitude of the station $156^\circ\ 16'.1+28'.4=156^\circ\ 44'.5$ west of Greenwich. Since neither the first (nautical result) nor the last result (depending on estimated direction and distance) can compare in accuracy with the value deduced at the station I shall adopt the value $\varphi=71^\circ\ 17'.7$.

The longitude adopted results from a chronometric determination made by the supply expedition in the summer of 1882 in the Leo, under the command of Lieutenant Powell, Signal Corps, U. S. A. The result as worked out by Mr. W. Upton, computer in the office of the Chief Signal Officer, is given in his report appended to "Signal Service Notes No. V. Work of the Signal Service in the Arctic Regions; prepared under the direction of General Hazen, Washington, 1883." It depends on four chronometers, the sea rates of which could be established from observations at San Francisco before and after the voyage and at Plover Bay, East Siberia, during the voyage, though neither at Plover Bay nor at Ooglaamie did the weather prove favorable. Mr. Upton's result is $10^h\ 26^m\ 39^s \pm 10^s$ or $156^\circ\ 39'\ 45'' \pm 2'\ 30''$. It will be seen that this result is intermediate between that derived from dead reckoning on board the Golden Fleece and from the English determination of their station in 1853 to the southward and eastward of Barrow Point and referred to our station. Moreover, we have two sets of lunar distances from the sun July 7, 1882, with the resulting longitude $10^h\ 25^m\ 57^s$, and a set of lunar distances from Jupiter as observed at Point Barrow and referred to Ooglaamie by the addition of $1^m\ 25^s$, giving the result $10^h\ 27^m\ 14^s$. The mean of these two astronomical determinations is $10^h\ 26^m\ 36^s$, which agrees so well with the above chronometric value that I have adopted the latter, viz:

$$\lambda=10^h\ 26^m\ 39^s \text{ or } 156^\circ\ 39'\ 45'' \text{ west of Greenwich.}$$

For the magnetic work we need the difference of longitude between Ooglaamie and Göttingen, Germany. Taking the latter place, $0^h\ 39^m\ 46^s.2$ east of Greenwich, we have the required difference $11^h\ 06^m\ 25^s \pm 10^s$, by which amount Göttingen is east of Ooglaamie.

The magnetic work at Ooglaamie, 1881–'2–'3.—The necessary buildings were erected without delay. October 3, 1881, the party was housed. October 17 the meteorological observations were commenced and the instruments were mounted in accordance with the plan furnished with the

* Called Ootivakh on Ivon Petroff's map of Alaska; Tenth Census of the United States; Washington, 1882. The name Kokmullit given on this map is that of an Esquimaux settlement at Point Barrow; it is called Noowook on the Admiralty chart of 1853 (No. 2164).

† Report to Chief Signal Officer of September 15, 1881.

instructions, but it was not till the 1st of December that the magnetometers were adjusted and the regular hourly magnetic observations were recorded. Lieutenant Ray remarks: *

"The three magnetic instruments were mounted on wooden piers, the season being too far advanced to place masonry. Posts 12 inches square were set into the frozen earth to a depth of 1 foot and cemented into their place by pouring water around them and allowing it to freeze. These piers answered every purpose, were perfectly solid, and did not change their position in the slightest degree, and when the observatory was taken down this summer I found the ice around their base unmelted. As soon as the weather was warm enough, brick piers capped with stone were placed, and the instruments are now all in position on permanent piers."

This operation occasioned an interruption in the hourly observations from July 22 to July 30, 1882. This first series closed with September 9, 1882. It includes term-day observations, also hourly observations of dipping needle deflected by a constant weight as a substitute for a vertical force measure. These latter observations of relative total force, while of small value as differential measures, may nevertheless supply means for computing changes in the intensity which otherwise would have been wanting.

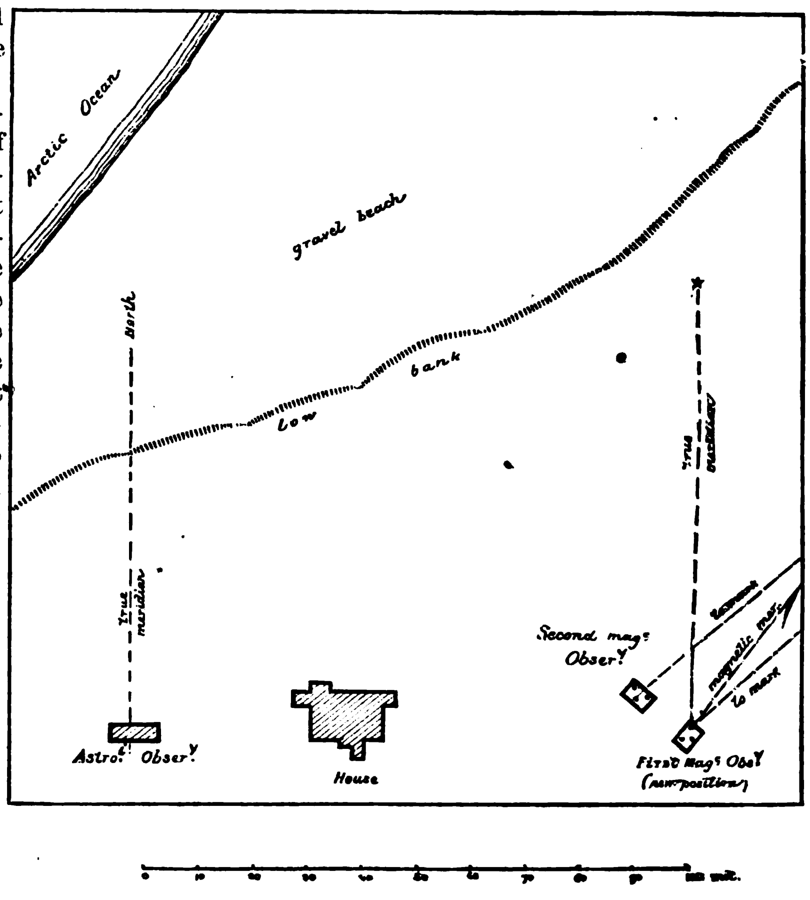
The supply party in the Leo arrived off Ooglaamie August 20, 1882, with the Brooke magnetometers. They were mounted on brick piers in a building specially erected for them, and their relative position was in strict conformity with the plan contained in the instructions. So long as thawing weather continued these piers lacked somewhat in stability, but the frost soon rendered them immovable. These instruments having been adjusted, the hourly series of observations commenced September 12, 1882, and was continued without interruption to August 27, 1883. The term-day observations and those for absolute measure were continued throughout the second year of the occupation of the place.

It has already been mentioned that in consequence of unfavorable conditions between August 22 and August 29 (when the station was abandoned) no verification of the magnetic work could be made by Mr. R. A. Marr, but on the return voyage some magnetic observations were secured at Unalashka, and after the return of the instruments to Washington some additional verification work was done by Sergeant Maxfield in January and February, 1884.

The accompanying sketch shows the location of the magnetic observations and the position of the instruments.

The first position of the magnetic observatory was a little to the westward of the new position shown on the sketch; the change was made in July, 1882.

U. S. Polar Station Ooglaamie, Alaska.



* In his report to the Chief Signal Officer, dated at Ooglaamie August 25, 1882.

PART II.—ABSOLUTE MEASURES.

MONTHLY VALUES OF THE MAGNETIC DECLINATION, DIP, AND INTENSITY AT OOGLAAMIE, DECEMBER, 1881, TO AUGUST, 1883.

RESULTS OF THE MAGNETIC DECLINATION.

The horizontal direction of the magnetic force at Ooglaamie was determined by means of Fauth & Co.'s magnetometer, Coast and Geodetic Survey, No. 11, mounted on the northern pier of the magnetic observatory, built soon after the arrival of the party; in July, 1882, it was shifted to a new position, where it remained to the close of the work. This instrument served for the absolute as well as for differential or variation measures; the latter observations, however, were discontinued on the arrival in the second year of the Brooke variation instruments. The instrument was not well adapted for differential work, as has been stated.

From returns brought home in the "Leo" it was evident that the declinations were defective, for some reason not then apparent; also that the magnet, which was a new one, had parted with much of its magnetism. It became desirable, therefore, practically to test the condition of the instrument for accurate work as soon as this could be done. It was returned to the office at Washington, January 12, 1884, and after undergoing some trifling repairs due to defective packing, Sergeant Maxfield was directed to determine the declination with it at the magnetic observatory in this city,* also to furnish some additional measures of the instrumental constants, those obtained by Sergeant Smith in June, 1881, not being deemed sufficient. These measures proved that the instrument was still in a satisfactory condition.

When the full returns came to hand it became evident that the discrepancies noticed in the monthly values of the declination were due to a want of attention to the suspension fiber. The plane of detorsion was apparently placed in the magnetic meridian in December, 1881, but no further test or adjustment was made till March, 1883; during this period the force of torsion had gradually increased (from unknown causes) and affected the declination to the amount of nearly $5\frac{1}{2}°$ in September, 1882; after this date this deflection remained perfectly steady until removed in March, 1883.

For the first six months the monthly results refer to the mean declination of the day (from twenty-four hourly values), but after the arrival of the Brooke differential instruments the declinations were referred to the mean of the respective months through hourly corresponding readings of the Fauth & Co. magnetometer No. 11 and the Brooke declinometer. These corresponding readings generally extend over six hours on each day of observation.

The record and computation of the absolute measures are contained in Appendix II, not submitted herewith. Placing little reliance on the determination in December, 1881, on account of a weak astronomical azimuth, and omitting for the present all results of 1882 and those for 1883 up to the middle of March, we have the following reliable values, which rest on a new astronomical azimuth determined July 25, 1882, and which are roughly checked by a second measure taken on the Brooke declination pier August 31, 1882, the same mark† being used and all distances being known. The observations of July 31 are rejected, there being apparently an error of about $4\frac{1}{2}°$.

* The observations made February 5 and 7, 1884, gave for the declination 3° 57′.9 west. The same computed from annual determinations made at Washington, D. C., since 1877, is 4° 00′.4 west; difference 2′.5. The measures for intensity were equally satisfactory.

† Distance magnetometer No. 11 to mark 900 feet, and to Brooke declinometer 39.5 feet. First position of instrument November 21, 1881, azimuth of mark on house 96° 13′ west of north, from observations on Jupiter; second position of instrument July 25, 1882, mark 46° 36′ east of north, from observations of the sun.

Table of resulting magnetic declinations at Ooglaamie station.

[Values reduced to mean of month by means of the differential observations.]

Date.	Declination.	Monthly mean values.		Corresponding mean of readings of Brooke declinometer.
1883.	° ′	1883.	° ′	*Divisions.*
Mar. 31	35 33.3 E.	March	— 35 33.3	484.7
Apr. 14	35 31.7	April	29.0	482.1
Apr. 30	35 26.4	May	28.6	476.0
May 14	35 30.8	June.........	11.8	475.7
May 31	35 26.3	July....	47.8	474.0
June 14	35 25.2	August......	30.1	473.5
June 30	34 58.3	Mean D =	—35 30.1	Mean 477.6 = r_0
July 14	35 47.8			
Aug. 14	35 30.1	Corresponding to the epoch June 1, 1883.		

The following results, except the first, are those affected by torsion; some of these we propose to use differentially; they are all reduced to the mean of the month respectively:

Date.	Declination.	Remarks.
1881.	° ′	
Dec. 11	35 15.7 E.	
1882.		
Jan. 24	37 28.8	
Apr. 18	39 49.9	
May 24	39 06.1	
June 17, 18	39 47.4	
July 19, 20	39 54.0	New position of instrument, and new azimuth used here.
Aug. 19	41 14.9	
Aug. 31	41 23.4	
Sept. 14	41 19.7	
Sept. 30	41 35.5	
Oct. 14	41 23.0	
Oct. 31	41 17.7	
Nov. 16	41 18.7	
ov. 30	41 14.7	
ec. 14	41 08.8	
1883.		
Jan. 1	41 15.1	
Jan. 14	41 10.3	
Jan. 31	41 24.7	
Feb. 14	41 26.1	
Feb. 28	40 16.7	Torsion partially removed by observer.
Mar. 14*	36 02.0	Observer attempted to take out the torsion.

* After this date the magnet was suspended on a single fiber; it had previously been suspended on two fibers.

Towards the middle of August, 1882, the deflecting force of torsion had become constant and remained so to the middle of February in the following year. For this period we have the following

means, and the corresponding monthly means of the readings r of the Brooke differential magnetometer, the mean correction to the absolute results is then found as shown below:

Date.	D′ observed declination.	Brooke declinometer r.	$\Delta r = r_0 - r$.	D + Δr.	Correction for torsion.	Corrected declination.
1882.	° ′		′	° ′	° ′	° ′
Aug. 19, 31	−41. 19. 2	....	....	... .	....	−35 44. 6
Sept. 14, 30	24. 6	(498. 0)	−20. 4	−35 50. 5	+ 5 34. 1	50. 0
Oct. 14, 31	20. 4	(495. 6)	18. 0	48. 1	32. 3	45. 8
Nov. 16, 30	16. 7	489. 8	12. 2	42. 3	34. 4	42. 1
Dec. 14	08. 8	489. 9	12. 3	42. 4	26. 4	34. 2
1883.						
Jan. 1, 14, 31	16. 7	488. 1	10. 5	40. 6	36. 1	42. 1
Feb. 14	26. 1	489. 4	11. 8	41. 9	44. 2	51. 5
				Mean	+ 5 34. 6	

The two values within parenthesis in column headed r are interpolated: Mean reading of declinometer for the last five months $476^d.2$ and for the preceding five months $488^d.4$, hence difference for five months $12^d.2$ or monthly change $2'.4$, and the first interpolated value becomes $4 \times 2.4 + 488.4 = 498.0$. The fifth column gives the computed declination corresponding to difference $r_0 - r$ or for the reading r, and the torsion correction is determined by the difference D — D′. Our completed series when compared with the preceding series (March to August, 1883) exhibits necessarily a trace of the comparatively rapid monthly decrease in the differential series between February, 1883 (mean 489.5), and May, 1883 (476.1), but the magnitude of the errors of observation of the absolute measures forbids any attempt at correction of the differential series. Omitting the value for August, 1882, we finally have the table of absolute values as follows:

Resulting monthly means of the magnetic declination at Ooglaamie.

Date.	Monthly mean.	Date.	Monthly mean.
1882.	° ′	1883.	° ′
September.	−35 50. 0	March.	−35 33. 3
October.	45. 8	April.	29. 0
November.	42. 1	May.	28. 6
December.	34. 2	June.	11. 8
1883.		July.	47. 8
January.	42. 1	August.	30. 1
February.	51. 5		−35 37. 2*

* Answering to the epoch March 1, 1883, which is preferred to the value deduced above for the epoch June 1, 1883. The corresponding value of the Brooke declinometer reading is 487.7

Respecting the annual change of the declination, due to the secular variation, we know from the general discussion of the secular variation, Appendix No. 12, Coast and Geodetic Survey Report for 1882, that the eastern declination in Alaska is now diminishing. The expression for the secular variation at the two stations nearest to Point Barrow, viz, Port Clarence, in $\varphi = 65° 17'$ and $\lambda = 166° 19'$ west of Greenwich, and Chamisso Island, in $\varphi = 66° 13'.3$ and $\lambda = 161° 48'.7$ west of Greenwich, give for the annual change in 1880 and 1885 the values + 10′.3 and + 11′.3 for Port Clarence, and + 10′.7 and + 12′.0 for Chamisso Island, and we have to expect a greater value at Point Barrow. Captain Maguire determined the declination at that place in 1853 and found − 40° 21′, or, when reduced to Ooglaamie, about − 40° 36′, which, compared with our value above, gives almost exactly a diminution of 5° between 1853 and 1883. It is known from the other stations that this declination has not passed through a maximum within the last thirty years, but has diminished gradually with an accelerating rate. For uniform speed the annual change would be +10′; it is therefore probably near +15′ for the present time. The absolute measures, September,

1882, to August, 1883, would give the value + 28′.4, which is known to be much too great, and if we fall back on the differential series we obtain a value but a trifle less and undoubtedly affected by torsion in the suspension skein of the declinometer, which was never re-examined after the first adjustment had been made. Omitting the readings between March and April, when the torsion was most pronounced, a discussion of the five monthly means, November, 1882, to February, 1883, inclusive give a monthly change $m = -0'.97$, and a discussion of the four monthly means, for May, June, July, and August, 1883, give $m = -1'.15$, but if April be included $m = -1'.92$, mean $= -1'.53$; mean of first and last value $-1'.25$, hence annual change $-15'.0$, which is adopted as the most probable value.

RESULTS OF THE MAGNETIC DIP.

The observations were made with Kew dip circle,* L. Casella (London), No. 4370, or Coast and Geodetic Survey No. 23. It remained mounted on its pier in the small magnetic observatory during the stay at Ooglaamie. The instrument left Washington June 23, 1881, and was returned January 12, 1884, only sustaining the breakage of one of the dipping needles. Test observations made by Sergeant Maxfield at Washington in January and February, 1884, on four days, gave very satisfactory results. (See results for intensity.)

Observations were generally made on three days each month. The series commences with November 30, 1881, and ends with August 14, 1883. It does not appear that there is any appreciable difference in the results by needles 1 and 2; they are therefore combined indiscriminately. The following monthly means are made up from the individual results, and they are here arranged with a view of deducing, if practicable, from the monthly values taken at an interval of a year, a value for the annual change of the dip, independent of any annual variation:

1.—*Table of resulting dip at Ooglaamie.*

Date of observations.		Observed dip $\theta_,$.	Date of observations.		Observed dip $\theta_{,,}$.	Annual change. $\theta_{,,}-\theta_,$.
1881.		° ′	1882.		° ′	′
December	−1, 17, 18, 19.	81 24.6	December	14	81 22.4	−2.2
1882.			1883.			
January	18, 19, 20	22.4	January	1, 14, 31	22.0	−0.4
February	16, 17, 18	27.1	February	14, 28	24.8	−2.3
March	17, 18, 19	27.6	March	14, 25	25.0	−2.6
April	17, 18, 19	24.3	April	−1, 14, 30	24.5	+0.2
May	17, 18, 19	22.2	May	14, 23	22.6	+0.4
June	16, 18, 19	24.0	June	−1, 14, 30	23.9	−0.1
July	17, 18, 19	21.5	July	14, ½ {31, 45}	19.2	−2.3
August	17, 18, 19	22.8				
September	−1, 14, 30	22.2	Means		81 23.4	−1.2
October	14, 31	22.6				
November	16, 30	22.8				

Mean dip from twenty months of observation, 81° 23′.4, answering to the epoch October 1, 1882. Annual diminution of the dip 1′.2

Applying the effect of the secular variation, or, more properly, of the annual change to the mean monthly values, *i. e.*, to $\frac{1}{2}(\theta_, + \theta_{,,})$ for the months from December to July, inclusive, and to $\theta_,$ the correction $-0'.6$ for the months of August, September, October, and November, we obtain the following table of monthly dip values, all reduced to the same epoch and which, therefore, should indicate any annual variation that may exist, unless in consequence of the smallness of such variation it be hidden by the observing errors.

*Figured in Coast and Geodetic Survey Report for 1881, Appendix No. 8, Plate No. 37.

2. *Table of mean monthly dips reduced to the same epoch* (*December*, 1882).

Date, middle of month.	Mean dip.	Correction for annual change.	Dip referred to epoch.
	° ′	′	° ′
Dec., 1881 & 1882.	81 23.5	− 0.6	81 22.9
Jan'y, 1882 & 1883.	22.2	− 0.5	21.7
Feb., " " "	25.9	− 0.4	25.5
Mar., " " "	26.3	− 0.3	26.0
Apr., " " "	24.4	− 0.2	24.2
May, " " "	22.4	− 0.1	22.3
June, " " "	23.9	+ 0.1	24.0
July, " " "	20.4	+ 0.2	20.6
Aug., 1882+6 months.	22.2	+ 0.3	22.5
Sept., " "	21.6	+ 0.4	22.0
Oct., " "	22.0	+ 0.5	22.5
Nov., " "	22.2	+ 0.6	22.8

If the results exhibited in the last column of the table can be trusted for such small differences from the mean (81° 23′.1), they would indicate a slightly greater dip about the time of the vernal equinox and a slightly smaller dip about the time of the autumnal equinox.

The probable uncertainty of a monthly determination of the dip, *i. e.*, of any one of the values $\theta_{\prime}$ or $\theta_{\prime\prime}$ is found to be $\frac{2'.5}{\sqrt{3}} = \pm\ 1'.4$ about.

Observations at Washington, D. C.; at Toronto, Canada; at Madison, Wis.; at Esquimault, British Columbia; at Sitka, Alaska, and at many intermediate places (see preface to "Diary of a magnetic survey of a portion of the Dominion of Canada," by General Sir J. H. Lefroy, London, 1883), show that the dip as well as the total intensity of the magnetic force are at the present time, and have been for some years past, slowly *decreasing*, and our result at Ooglaamie is conformable with this general and extended action of the secular change. General Lefroy also states that at Fort Rae, Great Slave Lake, the present rate of the secular variation is—1′.7 per annum, determined from comparisons of observations by Capt. H. P. Dawson with an earlier deduction. Both at Washington and Toronto the dip reached a maximum in 1859, at which time it is nearly certain that the total force had been declining for some years. In 1853, Captain Maguire, R. N., found the dip at Plover Point, about 2½ nautical miles southeast of Barrow Point, 81° 36′ (Phil. Trans. Royal Society, 1857, vol. 147, Part II, London, 1858), indicating an apparent diminution of 13′ in twenty-nine years, but it is highly probable that since Captain Maguire's occupation of this point the dip was on the increase for a few years before its present reversed motion commenced.

HORIZONTAL COMPONENT, VERTICAL COMPONENT AND TOTAL MAGNETIC FORCE.

The observations for horizontal force were made with magnetometer Coast and Geodetic Survey No. 11, mounted on its pier in the small magnetic observatory. On its return to Washington in January, 1884, the glass tube was found broken; it was replaced by a spare tube, and after repairing some trifling damages, additional observations were made here by Sergeant Maxfield for a better determination of the instrument constants.* He also made the observations of deflections by gravity and by magnetism with the Lloyd needle of dip circle No. 23, which were required to furnish the constant for converting relative total intensity into absolute measure.

Constants of magnetometer No. 11.—Mass of ring 300.767 grains, outer diameter 3.799 centimeters, inner diameter 2.953 centimeters, thickness 0.529 centimeters, measured April 29, 1881 at 77° Fah.;

*The following results were deduced from Sergeant Maxfield's observations at Washington: January 28, 1884, H = 4.375 (English units); dip January 30, 31, February 1, 2, 1884, $\theta = 70°\ 37'.3$; hence F = 13.185 These results compare favorably with the values deduced (and referred to same time) from eighteen years of annual determinations in the same place, viz:

$$H = 4.378, \quad \theta = 70°\ 39'.4, \quad F = 13.218$$

again, from measures on April 30 at 73° Fah., outer diameter 1.4895 inches, inner diameter 1.160 inches, thickness 0.208 inch; the ring is of bronze. Moment of mass M, at any temperature t (Fah.) in units of feet and grains $= 0.93070\ [1 + .00002\ (t - 75°)]$. From observations of oscillations of long or intensity magnet L 11 with and without ring, by Sergeants Smith, in June, 1881, and Maxfield in January, 1884, we have at the temperature of 62° Fah.:

	M	w
June 10, 1881.	0.87898	1
June 11, 1881.	0.87761	2
June 17, 1881.	0.87723	7
Jan. 28, 1884.	0.87515	3
Weighted mean M=	0.87694	

Hence M for any temperature t (Fah.)

$$M = 0.87694\ [1 + .0000136\ (t - 62°)].$$

Length of collimator magnet L11, 2.48 inches, diameter 0.33 inch, about; length of shorter magnet S11, 2.04 inches, diameter 0.34 inch, about. Scale of declination magnet L11, 80 divisions; angular value of a scale division 3′.69 The temperature coefficient determined from the monthly observations of the intensity at Ooglaamie was found to equal $q = .00085$, a value rather large and probably related to the rapid loss of magnetism of L11 when first magnetized; the magnetic moment, m, of this magnet changed from about 0.0693 (English units) in December, 1881, to 0.0671 in January, 1884.

From the monthly observations at Ooglaamie the following results were deduced:

Table of resulting values for magnetic horizontal force (H) *at Ooglaamie, as determined by magnetometer No.* 11 *from oscillations and deflections, and expressed in English units.*

Date of observations.	H.	m. at 62° F.	Date of observations.	H.	m. at 62° F.	Apparent annual change Δ H.
1881.			1882.			
December 17, 18, 19.	1.932	.0671?	December 14.	1.955	.0679	+ 0.023
1882.			1883.			
*January 18, 19, 20.	1.916	.0693	January 1, 14, 31.	1.930	.0681	.014
February 16, 17, 18.	1.930	.0690	February 14, 28.	1.942	.0675	.012
March 17, 18, 19.	1.912	.0696	March 14, 31.	1.928	.0683	.016
* April 17, 18, 19.	1.946	.0690	April 14, 30.	1.956	.0669	.010
May 17, 18, 19.	1.923	.0692	May 14, 31.	1.954	.0676	.031
June 17, 18, 19.	1.936	.0690	June 14, 30.	1.955	.0662	.019
July 18, 19, 20.	1.924	.0695	July 14, 31.	1.930	.0670	.006
August 17, 18, 19.	1.948	.0685	August 14.	1.956	.0660	.008
September —1, 14, 30.	1.939	.0685	Mean	1.939	.0681	+ 0.015
October 14, 31.	1.936	.0686				
November 14, 30.	1.972	.0682				

* Oscillations, alone, on January 18, 19, and April 17.

Mean horizontal component of magnetic intensity from 21 months of observation 1.939 (English units), for epoch October (middle) 1882.

Annual apparent increase + 0.015

From evidence similar to that given for the dip, but less conclusive, it is probable that H is on the increase, though the above amount appears far too large. In the discussion of Captain Maguire's observations at Barrow Point in 1852–'3–'4, Sir Edward Sabine assumes H for that epoch about 1.79; this value, when compared with the above, would indicate an annual increase of about + 0.005

SECOND AND INDEPENDENT DETERMINATION OF THE HORIZONTAL FORCE BY MEANS OF THE KEW DIP CIRCLE, ACCORDING TO DR. LLOYD'S METHOD* OF DEFLECTIONS BY GRAVITY AND BY MAGNETISM IN CONJUNCTION WITH DIP OBSERVATIONS.

This method has the great advantage of being independent of the temperature and of any loss of magnetism of the needle, and applies well for stations in high magnetic latitude.

The monthly observations for intensity with the dip circle at Ooglaamie commence in June, 1882, and terminate with August, 1883.

Washington, D. C., was selected as a base station and the value of the constant

$$A = H_0 \sec \theta_0 \sqrt{\sin u_0 \sin u'_0 \sec \eta_0}$$

became known from the observations of Sergeant Maxfield in January and February, 1884. We have for the deflecting weight employed at Ooglaamie previous to September, 1882, the values:

$\eta_0 = 41° 04'.4$ from 12 sets of observations, Lloyd's needle No. 4 weighted; February 15, 1884.

$\theta_0 = 70° 39'.4$ from annual observations for eighteen years, 1867 to 1884, reduced ot February, 1884.

$u_0 = 29° 35'.0$

$u'_0 = 37° 19'.1$ from 12 sets of observations, Lloyd's needle No. 4, deflecting No. 3, February 15, 1884.

Hence log $A = 0.92055$ using $H_0 = 4.378$ as deduced from annual observations for eighteen years, 1867 to 1884, reduced to February, 1884.

For the deflecting weight employed at Ooglaamie after August, 1882, we have:

$\eta_0 = 41° 34'.6$ from 7 sets of observations, Lloyd's needle No. 4 weighted; January 30, 31, February 1, 2, 1884.

$\theta_0 = 70° 37'.3$ from 10 sets of observations, dip circle No. 23.

$u_0 = 29° 02.7$

$u'_0 = 37° 16'.0$ from 7 sets of observations, Lloyd's needle No. 4, deflecting No. 3; dates as above.

Hence log $A = 0.91759$

The results at Ooglaamie are then worked out by the formula:

$$H = A \cos \theta \sqrt{\cos \eta \operatorname{cosec} u \operatorname{cosec} u'}$$

which were tabulated as follows:

Table of resulting values for magnetic horizontal force (H) *at Ooglaamie, as determined by Kew dip circle No. 23, from gravity and magnetic deflections.*

Date of observations.	H.	Date of observations.	H.
1882.		1883.	
June 16, 18, 19.	1.945	February 14, 28.	1.922
July 17, 18, 19.	1.958	March 14, 31.	1.928
August 17, 18, 19.	1.930	April 14, 30.	1.918
September—1, 14, 30.	1.934	May 14, 31.	1.928
October 14, 31.	1.958	June 14, 30.	1.929
November 16, 30.	1.930	July 14, 31.	1.935
December 14.	1.928	August 14.	1.933
1883.		Mean	1.935
January 1, 14, 31.	1.944		

Mean horizontal component of magnetic intensity from fifteen months of observations 1.935 (English units) for the epoch January (middle), 1883, with apparently an annual diminution.

*Directions for measurement of terrestrial magnetism, Coast and Geodetic Survey Report for 1881, Appendix No. 8, p. 145, Art. (16).

The mean values for H by the two instruments and methods agree well, and the monthly values may therefore advantageously be united as shown below:

Date.	H by magnetometer.	H by dip circle.	Mean adopted.	Date.	H by magnetometer.	H by dip circle.	Mean adopted.	Apparent annual change.
1881.				1882.				
December.	1.932	......	......	December.	1.955	1.928	1.941	+.009
1882.				1883.				
January.	1.916	......	......	January.	1.930	1.944	1.937	+.021
February.	1.930	......	......	February.	1.942	1.922	1.932	+.002
March.	1.912	......	......	March.	1.928	1.928	1.928	+.016
April.	1.946	......	......	April.	1.956	1.918	1.937	—.009
May.	1.923	......	......	May.	1.954	1.928	1.941	+.018
June.	1.936	1.945	1.940	June.	1.955	1.929	1.942	+.002
July.	1.924	1.958	1.941	July.	1.930	1.935	1.932	—.009
August.	1.948	1.930	1.939	August.	1.956	1.933	1.944	+.005
September.	1.939	1.934	1.936			Mean	1.936	+.006
October.	1.936	1.958	1.947					
November.	1.972	1.930	1.951					

Mean H from twenty-one months of observation 1.936, answering to the epoch October (middle) 1882. Annual increase, approximately, 0.006

The following table contains the resulting monthly values for the horizontal, the vertical, and the total intensity, the last two quantities computed from the relations

$$V = H \tan\theta \qquad \text{and} \qquad F = H \sec\theta$$

In order to facilitate comparisons of similar quantities at other stations, using different units of measure, the values of H, V, F at Ooglaamie are given in the table expressed in the three different systems of units at present in use, viz, the English system, in feet, grain, second units; the Gaussian system, in mm., mg., second units; and the British Association, or C. G. S., in cm., gm., s. units, or dynes.

Resulting horizontal, vertical and total magnetic force at Ooglaamie.

Date.	Dip θ.	Horizontal force, H.			Vertical force, V.			Total force, F.		
		English units.	Gaussian units.	C. G. S. dynes.	English units.	Gaussian units.	C. G. S. dynes.	English units.	Gaussian units.	C. G. S. dynes.
1881.	° ′									
December.	81 24.6	1.932	0.8908	.08908	12.790	5.897	.5897	12.935	5.964	.5964
1882.										
January.	22.4	1.916	0.8834	.08834	12.629	5.823	.5823	12.774	5.890	.5890
February.	27.1	1.930	0.8899	.08899	12.840	5.920	.5920	12.984	5.987	.5987
March.	27.6	1.912	0.8816	.08816	12.733	5.871	.5871	12.875	5.936	.5936
April.	24.3	1.946	0.8973	.08973	12.875	5.936	.5936	13.024	6.004	.6004
May.	22.2	1.923	0.8867	.08867	12.670	5.842	.5842	12.816	5.909	.5909
June.	24.0	1.940	0.8945	.08945	12.828	5.915	.5915	12.974	5.982	.5982
July.	21.5	1.941	0.8950	.08950	12.772	5.889	.5889	12.918	5.956	.5956
August.	22.8	1.939	0.8940	.08940	12.791	5.898	.5898	12.937	5.965	.5965
September.	22.2	1.936	0.8927	.08927	12.756	5.882	.5882	12.902	5.949	.5949
October.	22.6	1.947	0.8977	.08977	12.839	5.920	.5920	12.986	5.988	.5988
November.	22.8	1.951	0.8996	.08996	12.870	5.934	.5934	13.017	6.002	.6002
December.	22 4	1.941	0.8950	.08950	12.794	5.899	.5899	12.941	5.967	.5967
1883.										
January.	22.0	1.937	0.8931	.08931	12.758	5.882	.5882	12.904	5.950	.5950
February.	24.8	1.932	0.8908	.08908	12.795	5.900	.5900	12.940	5.966	.5966
March.	25.0	1.928	0.8890	.08890	12.774	5.890	.5890	12.918	5.956	.5956
April.	24.5	1.937	0.8931	.08931	12.820	5.911	.5911	12.966	5.978	.5978
May.	22.6	1.941	0.8950	.08950	12.799	5.901	.5901	12.946	5.969	.5969
June.	23.9	1.942	0.8954	.08954	12.838	5.919	.5919	12.984	5.987	.5987
July.	19.2	1.932	0.8908	.08908	12.655	5.835	.5835	12.802	5.903	.5903
August.	81 (22.2)	1.944	0.8963	.08963	12.809	5.906	.5906	12.956	5.974	.5074
Mean, (Oct., 1882)	81 23.4	1.936	0.8927	.08927	12.786	5.895	.5895	12.932	5.963	.5063

To an annual change of $\delta\theta$ in the dip θ and an annual change δH in the horizontal component of the force H there correspond annual changes of δV and δF in the vertical component, V, and in the total force, F, respectively, viz:

$$\delta V = \tan\theta\,\delta H + H\sec^2\theta\,d\theta \qquad \delta F = \sec\theta\,\delta H + H\sin\theta\sec^2\theta\,d\theta$$

hence for $\delta\theta = -1'.2$ and $\delta H = +0.006$, we find $\delta V = +0.010$ and $\delta F = +0.010$ in English units, and in dynes with $\delta H = +.00028$, $\delta V = .00046$ and $\delta F = .00046$

The topography of the accompanying map is compiled from surveys of 1853 (by Captain Maguire, R. N.), and of 1881–'83 (by Lieutenant Ray, U. S. A.); for the positions and names of the small lakes northeast of Ooglaamie I am indebted to Sergeant Murdoch. The two astronomical stations are laid down by their observed latitudes and longitudes. The distribution of the magnetic declination for 1883 is shown by two isogonic lines, the direction and distance of which are taken from my paper on the distribution of magnetism in the United States (Coast and Geodetic Survey Report for 1882, Appendix No. 13). The isoclinic and isodynamic (horizontal force) lines incline about 50° west of north, or about 5° more than the isogonic lines, but no precise data are available.

PART III.—DIFFERENTIAL MEASURES.

HOURLY VARIATIONS OF THE DECLINATION, HORIZONTAL AND VERTICAL INTENSITIES WITH BI-MONTHLY TERM-DAY READINGS, AT OOGLAAMIE; DECEMBER, 1881, TO AUGUST, 1883.

DIFFERENTIAL MAGNETIC OBSERVATIONS AT OOGLAAMIE, NEAR POINT BARROW, ALASKA.

I. The observations of the first year of occupation consist of hourly readings of the Fauth & Co. magnetometer, Coast and Geodetic Survey No. 11; of the bifilar magnetometer, Coast and Geodetic Survey No. 2; and of dip circle, Coast and Geodetic Survey No. 23, comprising *variations* in the magnetic declination, in the horizontal and in the total intensities between December, 1881, and September, 1882; together with term-day readings at the beginning and middle of each month, as agreed upon for the Polar stations. There were four observers, viz: Sergt. James Cassidy, Sergt. John Murdoch, Sergt. Middleton Smith, and A. C. Dark. They took regular turns, each observing four hours at a time. Fifteen readings were taken each hour, five for each instrument, viz: six minutes and three minutes before and after and at the full hour, commencing with the declinometer and immediately followed by readings of the bifilar and dip instruments. The temperature was noted. The presence of an aurora is indicated by an asterisk.

The instrumental outfit of the second year of occupation being far more complete than that of the first year, only so much of the record and discussion of the first year's work will be given here as seems desirable; further consideration will be given to this year's record after the presentation of the second year's work.

II. The observations of the second year of occupation consist of hourly readings of the Brooke magnetometers, comprising *variations* in the magnetic declination, in the horizontal intensity and in the vertical intensity between September, 1882, and August, 1883, together with term-day readings on the 1st and 15th of each month, as agreed upon for the Polar stations. The observations were made by six observers, viz: Sergeants Murdoch and Smith and Mr. Dark, as in the previous year, and Sergt. J. E. Maxfield with Privates C. Ancor and J. Guzman; they took watches of four hours each in regular rotation. Six readings were taken every hour, viz: the horizontal force magnetometer was read one and one-half minutes before and again one and one-half minutes after the full hour, the declinometer was read one minute before and one minute after, and the vertical-force magnetometer one-half minute before and one-half minute after the full hour. The temperature was noted by two thermometers suspended inside the cases or zinc covers of the horizontal-force magnetometer and of the declinometer. Suitable centigrade thermometers had been ordered, but they were not received in time and none was placed inside the case of the vertical-force magnetometer; the temperature of this magnet can be inferred from the mean of the readings of the thermometers of the other instruments, which rarely deviated more than half a degree. The presence of an aurora is indicated by an asterisk.

ADJUSTMENT OF THE BROOKE DIFFERENTIAL MAGNETOMETERS.

THE UNIFILAR MAGNETOMETER.

The length of one division of the scale is 1 millimeter; the radius, mirror to scale is 1.719 meters; hence the angular value of one division of the scale = 1′.

(1.) Observations for torsion coefficient, September 9, 1882, 1^h p. m. When in the magnetic meridian the plane of detorsion read 164° 30′, and by turning the torsion circle 90°, first backward,* next forward, and again to first position, we have the readings:

Torsion circle.	Scale readings.	Mean.	Differences.
° ′	d. d.	d.	d. °
164 30	530 left, 519 right	524.5	
			88.5 for 90
74 30	456 left, 416 right	436.0	
			155.5 for 180
254 30	684 left, 499 right	591.5	
			88.5 for 90
164 30	770 left, 236 right	503.0	

Mean deflection, $a = 83'.1$, for $\beta = 90°$; hence $\frac{h}{f} = \frac{83.1}{5316.9} = 0.01563$; and the scale value $a = 1'.016$

The fixed mirror was set to show scale division 50 bisected, and at 0^h 08^m (September 10) a. m., Göttingen mean time, the magnetometer (movable mirror) was set to read 524.

(2.) On November 1, 4^h 52^m p. m., Göttingen time, both mirrors set to read 500.

(3.) The instrument was readjusted November 3, 6^h 10^m p. m. At 3^h 47^m p. m. the plane of detorsion was found to read 51° 52′, when the following observations were made:

Torsion circle.	Scale readings.	Differences.
° ′	d.	d. °
51 52	486	
		106 for 90
141 52	592	
		208 for 180
321 52	384	
		103 for 90
51 52	487	

Mean deflection, $a = 104'.3$, for $\beta = 90°$; hence $\frac{h}{f} = \frac{104.3}{5295.7} = 0.01970$; and the new scale value $a = 1'.020$

Fixed mirror reads 500, and magnetometer (movable mirror) was set to 493 at 5^h 16^m a. m., November 4, Göttingen time.

Increasing scale divisions denote increasing easterly declination.

Recapitulation of monthly mean values (inclusive of disturbances) of hourly readings of the Brooke declinometer at Ooglaamie, Alaska, 1882–'83.

[NOTE.—For the purposes of this report it has been deemed sufficient to give the monthly mean values of the hourly readings of the Brooke declinometer. These values are tabulated as follows. The average scale reading 484.7 corresponds approximately to 35° 37′.2 east declination.]

Göttingen civil time.	0^h.	1^h.	2^h.	3^h.	4^h.	5^h.	6^h.	7^h.	8^h.	9^h.	10^h.	11^h.
Ooglaamie civil time.	$12^h 53^m.6$ Noon + $53^m.6$	$13^h 53^m.6$	$14^h 53^m.6$	$15^h 53^m.6$	$16^h 53^m.6$	$17^h 53^m.6$	$18^h 53^m.6$	$19^h 53^m.6$	$20^h 53^m.6$	$21^h 53^m.6$	$22^h 53^m.6$	$23^h 53^m.6$
1882.	Divisions.											
September (21).	491.7	492.3	495.9	493.8	491.7	492.8	490.4	496.0	495.9	487.0	474.7	492.8
October.	492.1	490.5	495.1	488.7	493.4	488.5	490.2	491.5	488.4	486.8	482.8	475.9
November.	485.8	484.8	484.7	487.0	481.3	479.9	486.1	486.5	471.4	466.2	493.4	454.3
December.	487.9	481.5	484.1	484.5	483.8	483.2	484.9	485.1	487.7	485.6	487.3	476.4
1883.												
January.	474.2	479.6	479.1	479.7	482.2	482.3	483.1	485.5	486.9	481.9	479.6	478.4
February.	476.2	476.0	479.3	479.8	478.9	479.0	481.4	478.2	489.1	478.0	485.6	483.7
March.	478.7	477.3	478.5	472.5	472.0	475.5	475.5	471.5	475.3	469.8	483.8	477.5

* The circle is graduated from left to right.

Recapitulation of monthly mean values, &c.—Continued.

Göttingen civil time.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
Ooglaamie civil time.	12h 53m.6 Noon+53m.6	13h 53m.6	14h 53m.6	15h 53m.6	16h 53m.6	17h 53m.6	18h 53m.6	19h 53m.6	20h 53m.6	21h 53m.6	22h 53m.6	23h 53m.6
1883.												
April.	474.8	473.1	471.2	467.2	467.0	467.6	471.7	474.3	472.8	471.6	470.4	472.3
May.	465.0	470.7	466.8	464.1	462.5	464.0	464.6	466.0	464.8	469.6	462.2	459.6
June.	467.2	470.0	464.0	461.7	462.8	463.7	464.0	471.3	465.8	459.2	458.0	461.6
July.	471.0	464.8	467.9	463.5	458.9	459.2	459.6	461.9	450.7	463.3	467.1	461.1
August (14).	464.2	463.5	462.2	464.2	463.1	462.2	463.7	476.4	470.7	466.1	462.8	461.6
April to September, inclusive.	472.3	472.4	471.3	469.1	467.7	468.2	469.0	474.3	470.1	469.5	465.9	468.2
October to March, inclusive.	482.5	481.6	483.5	482.0	481.9	481.4	483.5	483.1	483.1	478.1	485.4	474.4
Year.	477.4	477.0	477.4	475.6	474.8	474.8	476.3	478.7	476.6	473.8	475.6	471.3

Göttingen civil time.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
Ooglaamie civil time.	0h 53m.6	1h 53m.6	2h 53m.6	3h 53m.6	4h 53m.6	5h 53m.6	6h 53m.6	7h 53m.6	8h 53m.6	9h 53m.6	10h 53m.6	11h 53m.6	
1882.													
September (21).	492.0	499.5	500.0	507.2	509.2	506.9	518.3	512.4	506.5	502.4	497.9	492.9	497.5
October.	474.7	495.0	512.5	500.7	508.5	508.9	510.7	527.3	512.5	501.4	492.5	485.8	495.6
November.	474.2	495.1	470.6	493.5	517.6	504.0	538.9	517.8	514.9	498.3	487.4	483.0	489.8
December.	474.8	497.0	499.5	499.0	498.3	504.4	499.9	507.7	504.8	491.8	484.6	484.5	489.9
1883.													
January.	481.4	477.1	498.7	495.7	502.6	514.9	499.1	506.2	511.1	494.7	484.9	477.0	488.1
February.	476.4	476.6	507.7	491.6	507.9	513.6	513.6	513.8	494.5	505.4	491.1	487.6	489.4
March.	474.3	467.5	487.5	498.3	497.0	506.8	505.9	513.2	506.4	495.6	493.6	478.8	484.7
April.	476.6	479.2	487.7	485.8	494.7	503.9	506.8	514.4	500.6	495.7	492.6	479.0	482.1
May.	462.7	470.8	479.5	484.9	492.6	504.6	509.1	504.4	500.8	483.6	480.8	468.9	476.0
June.	456.8	467.3	472.5	478.7	487.6	508.0	518.1	502.0	512.7	493.2	482.5	468.8	475.7
July.	462.2	466.6	463.1	477.9	486.0	504.7	508.6	518.2	514.5	484.3	469.4	472.5	474.0
August.	456.4	465.6	476.8	477.6	485.9	495.0	500.0	499.0	495.9	487.9	475.5	467.4	473.5
April to September, inclusive	467.8	474.8	479.9	485.4	492.7	503.8	510.2	508.4	505.2	491.2	483.1	474.9	479.8
October to March, inclusive.	476.0	484.7	496.1	496.5	505.3	508.8	511.4	514.3	507.4	497.9	489.0	482.8	489.6
Year.	471.9	479.8	488.0	490.9	499.0	506.3	510.8	511.4	506.3	494.6	486.1	478.8	484.7

SOLAR-DIURNAL VARIATION OF THE DECLINATION, INCLUSIVE OF DISTURBANCES.

The daily variation of the magnetic declination is found by subtracting each hourly mean from the respective daily mean, and is given in the following table for the whole year, as well as for the half years, *i. e.*, with sun in north declination, and sun in south declination:

Göttingen civil time.	Ooglaamie civil time.	Apr.-Sept. ⊙ north declination.	Oct.-Mar. ⊙ south declination.	Year.	Göttingen civil time.	Ooglaamie civil time.	Apr.-Sept. ⊙ north declination.	Oct.-Mar. ⊙ south declination.	Year.
h.	m.	′	′	′	h.	m.	′	′	′
0	Noon+53.6	+ 7.5	+ 7.1	+ 7.3	Noon	M'n't+53.6	+12.0	+13.6	+12.8
1	13+53.6	+ 7.4	+ 8.0	+ 7.7	13	1+53.6	+ 5.0	+ 4.9	+ 4.9
2	14+53.6	+ 8.5	+ 6.1	+ 7.3	14	2+53.6	− 0.1	− 6.5	− 3.3
3	15+53.6	+10.7	+ 7.6	+ 9.1	15	3+53.6	− 5.6	− 6.9	− 6.2
4	16+53.6	+12.1	+ 7.7	+ 9.9	16	4+53.6	−12.9	−15.7	−14.3
5	17+53.6	+11.6	+ 8.2	+ 9.9	17	5+53.6	−24.0	−19.2	−21.6
6	18+53.6	+10.8	+ 6.1	+ 8.4	18	6+53.6	−30.4	−21.8	−26.1
7	19+53.6	+ 5.5	+ 6.5	+ 6.0	19	7+53.6	−28.6	−24.7	−26.7
8	20+53.6	+ 9.7	+ 6.5	+ 8.1	20	8+53.6	−25.4	−17.8	−21.6
9	21+53.6	+10.3	+11.5	+10.9	21	9+53.6	−11.4	− 8.3	− 9.9
10	22+53.6	+13.9	+ 4.2	+ 9.1	22	10+53.6	− 3.3	+ 0.6	− 1.4
11	23+53.6	+11.6	+15.2	+13.4	23	11+53.6	+ 4.9	+ 6.8	+ 5.9

Apparent diurnal range:

Six months, sun north of equator 44′.3

Six months, sun south of equator 39′.9

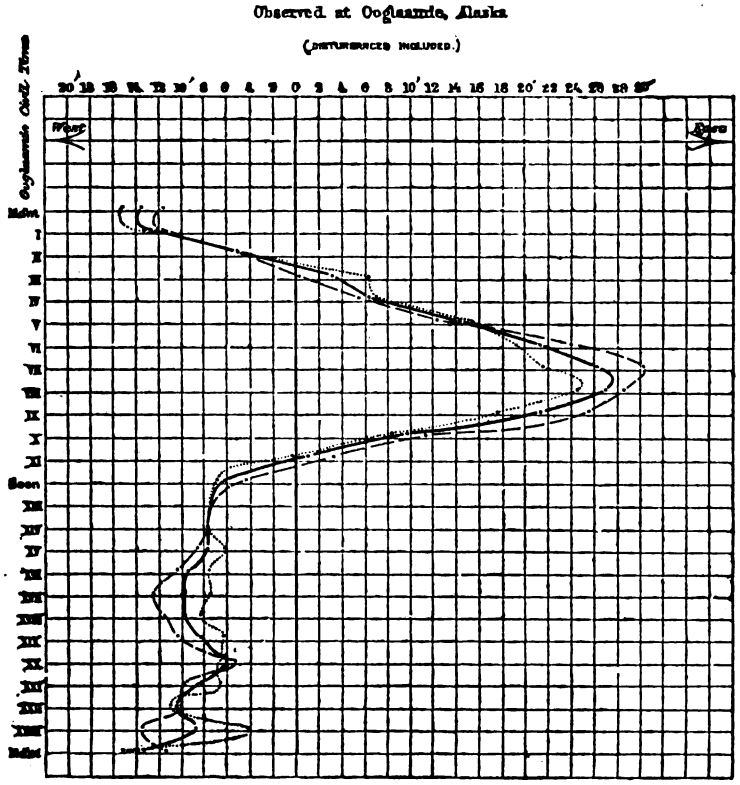
Year 40′.1

The most pronounced feature of the diurnal variation is the morning extreme easterly deflection between 7 and 8 a. m.; this is in perfect accord with the times of eastern elongation at stations in lower latitudes, thus at Sitka* 8 a. m.; at Madison, Wis., 8¼; at Toronto, 7¾; at Philadelphia, 7¾; and at Key West, 8¼. The afternoon westerly deflection, however, appears to be delayed when compared with stations to the south of Ooglaamie; we have a maximum about 5 p. m., and a

SOLAR DIURNAL VARIATION OF THE DECLINATION

Observed at Ooglaamie, Alaska

(DISTURBANCES INCLUDED.)



Full curve — mean of one year, Sept., 1882 to Aug. 1883.
Broken — mean of 6 months, sun in north declination.
Dotted — mean of 6 months, sun in south declination.

second and greater maximum about midnight, undoubtedly produced by disturbances, as shown in the accompanying diagram. At Sitka the westerly elongation occurs about 3½ p. m.; at Madi-

*It is much to be regretted that the magnetic observations taken at Sitka, Alaska, between 1848 and 1864 have never been fully discussed. As it appeared to me highly desirable to compare the diurnal variation of the declination at Ooglaamie with that of Sitka, I have made a combination of the hourly readings from the broken and irregular series extending from 1848 to 1862. (The material for this combination had been collected by Mr. M. Baker, of the Coast and Geodetic Survey, in March, 1882.)

Diurnal variation (inclusive of disturbances) of the declination observed at Sitka, Alaska, from ten years of observations.
[A + sign indicates deflection of north end of needle to the west; a − sign the opposite direction.]

Hour.	Variation.	Hour.	Variation.	Hour.	Variation.
	′		′		′
Midn't	+0.6	9	−5.3	17	+3.8
1	−0.2	10	−3.0	18	+3.2
2	−1.0	11	−0.6	19	+2.4
3	−1.4	Noon	+2.1	20	+1.4
4	−2.0	13	+3.2	21	+0.8
5	−2.9	14	+4.2	22	+0.4
6	−4.2	15	+4.6	23	+0.6
7	−5.3	16	+4.6	Midn't	+0.6
8	−6.0				

son, $1\frac{1}{2}$ p. m.; at Toronto, $0\frac{3}{4}$ p. m.; at Philadelphia, $1\frac{1}{4}$; and at Key West, $1\frac{3}{4}$. At Sitka there is no trace of the irregular western deflections recorded at Ooglaamie between 8 p. m. and about 2 a. m., as shown by the table in the foot-note. If we now refer to the observations made at Point Barrow during 1852–'53–'54 (Phil. Trans., vol. 147, 1857) we find 8 a. m. to be distinctly the hour of the maximum of the easterly disturbances which thus re-enforce the regular solar diurnal variation about this time and produce the great easterly deviation exhibited by the diagram. On the other hand, the westerly disturbances reach their maximum between the hours 11 p. m., midnight, and 1 a. m., when they obliterate the regular solar diurnal variation. Retaining the disturbances the eastern maximum deflection is recorded between 7 and 8 a. m.; excluding the larger ones it occurs near 7 a. m.; the western maximum, disturbances included, is recorded at 5 p. m. (with a second maximum between 10 and 11 p. m.), but excluding the larger ones the elongation reverts to 1. p. m.

It is also a noteworthy fact that the diurnal variation seems to depend little on the season, the deviations from the annual course for the half year with sun north of the equator and for the half year with sun south of the equator being small.

SEPARATION OF THE LARGER MAGNETIC VARIATIONS OR SO-CALLED DISTURBANCES, AND THEIR DISCUSSION.

In the present state of our knowledge there appears to be no other means of recognizing so-called disturbances in a series of observations except by their magnitude; that is, for any one observation or reading taken at random it is impossible to say how much of the measured quantity is due to the regular daily variations and how much to other variations following different laws. Having formed preliminarily for any one month hourly average or normal values and compared each observation at any hour with the normal at that hour, the series of differences so obtained will disclose the amount of the so-called disturbances, and a certain limiting value requires to be found which shall separate the apparently regular values from the supposed disturbed values, *i. e.*, those following different laws from the others.

In the discussion of that large body of magnetic material which had accumulated, mainly through the support of the British Government, about the middle of the present century, General Sir Edward Sabine was guided in his selection of a limiting value simply by practical considerations or by experience, and the eminent success which he had fully justified his method, yet when a number of simultaneous observations made at different stations, as in the case of the present Polar researches, require strict intercomparability of results, a more definite proceeding appears desirable.

I had made use of Peirce's criterion for the rejection of doubtful observations* —or, here more appropriately expressed, for the separation of observations deviating largely in amount by reason of their following different laws from those to which the ordinary observations are subject—and in using the criterion in such a case it was put forward only with a view of securing some definite rule, uniformly applicable.

The criterion was first employed by me in the discussion of Dr. Kane's magnetic observations of 1853–'54–'55 at Van Rensselaer Harbor, North Greenland;† afterwards for Dr. Bache's magnetic observations of 1840–'45 at Philadelphia,‡ and for the United States Coast Survey magnetic series of 1860–'66 at Key West, Florida.§ In these applications, where no great precision is required, its method of application may be much simplified; thus the mean deviation or the mean difference of any hourly value from its hourly normal may be found, without the trouble of forming squares, by the simple expression $\varepsilon = 1.25 \frac{[\triangle]}{N-1}$ and the limiting value given by the criterion will be $= x\,\varepsilon$, the value of x being a tabular value for the case $\mu=1$, and readily had from Chauvenet's Table X.

* U. S. Coast Survey Report for 1854, pp. 131-138; Gould's Astronomical Journal No. 83, Cambridge, Mass., April 24, 1855. It is now most readily accessible in Chauvenet's "Manual of Spherical and Practical Astronomy," Vol. II (first edition, Philadelphia, 1863).

† Smithsonian Contributions to Knowledge, Vol. X, 1858.

‡ U. S. Coast Survey Report for 1859, Appendix No. 22.

§ U. S. Coast Survey Report for 1874, Appendix No. 9.

The limit so found will be the widest one that may be employed, but in special applications it may require contraction, for the reason that the number of the largest disturbances is found to be insufficient for their successful discussion. Instead of using Peirce's criterion we can, however, arrive at an equally satisfactory fixation of a limit by means of the expressions of either the probable or the mean error of an observation.* We may define the widest limit as that deviation or difference from the mean which exceeds 3.5 times the probable variability or probable deviation of an observation; this limit corresponds to $\frac{3.5}{1.483}$ or to 2.36 times the mean deviation (as already used in connection with the criterion). Thus $2\frac{1}{3}$ times the mean deviation would be a superior limit, whereas Dr. Lloyd (1874) adopts for the discussion of the disturbances a limit of $1\frac{1}{2}$ times the average departure of a reading from its normal. By taking this lower limit we necessarily include a number of disturbances of lesser magnitude, but should the limit be drawn still closer there is danger of confusing the results with values following different laws from those which govern the larger disturbances. It would be most desirable to investigate the disturbances by a series of graduated limits and falling between these extremes. A limit somewhere between 2 and $1\frac{1}{2}$ times the mean deviation will probably be found most satisfactory. To find the mean deviation $\varepsilon=1.25\frac{\Sigma\triangle}{n-1}$ say from an hourly series of observations extending over one year, the diurnal as well as the annual variations of the disturbances must be taken into account, and it will suffice to deduce 24 numerical values for ε, using for the first month the hours 0 and 12, for the second month the hours 1 and 13, for the third the hours 2 and 14, etc., and, finally, to take the average (ε) from the 24 individual values so obtained.

Discussing the hourly variations of the declination recorded in the second year at Ooglaamie, where the horizontal components H =1.936 English units (=0.8927 Gaussian units, or 0.08927 dynes) for October, 1882, the value of ε equals 18′.4 nearly; hence limit by Peirce's criterion =44′, and the same for $2\frac{1}{3}$ times ε; for twice ε the limit is 37′, and for $1\frac{1}{2}$ ε it is 28′, which limits separate, respectively, 1 disturbed observation in 17 observations, 1 in 12, and 1 in 8. General Sabine's limit in the discussion of Captain Maguire's observations of 1852–'53–'54 was 22′.87, and the number of disturbances separated was between one-fifth and one-sixth of the whole number, but it should be remarked here that at that time we were approaching an epoch of a sun-spot minimum, whereas at present we have just passed through a sun-spot maximum, during which the disturbances are greater.

It has been noticed that a limit adopted for a station in low magnetic latitude will not serve to deduce a limit for a station in high magnetic latitude when having regard only to the supposition that the limits are inversely proportional to the magnitude of the horizontal components of their respective magnetic intensities. The disturbances appear to increase in greater ratio as we approach the magnetic Polar regions.†

The further discussion of the differential observations must be deferred until after a decision has been reached by the Fourth International Polar Conference (to meet shortly at Vienna) respecting the limit of recognition of disturbances (April 5, 1884).

The Bifilar Magnetometer.

The length of one division of the scale is 1 millimetre; the radius mirror to scale is 1.719 metres; hence angular value of one division of scale =1′.

(1.) Adjustment and determination of scale value September 11, 1882, 1^h p. m. With plane of detorsion in the magnetic meridian the torsion circle read 54° 42′. It was then turned, with the suspended weight, 90°, and read 324° 42′, in which position the fixed as well as the movable

* Here of course the differences of the tabular hourly readings from their respective hourly normals do not, in any sense, represent errors, every one being as correct as any other; they are variations governed by unknown laws probably of much complexity. The application of the formulæ of the method of least squares to such phenomena is more or less precarious; the pure observing error may be regarded as insignificant.

† Thus with the limit of 2′.6 at Key West (H=6.74) the Ooglaamie limit would be 9′, about; with the limit of 3′.6 at Philadelphia (H=4.17) the Ooglaamie limit would be 8′, about; with the limit of 5′.0 at Toronto (H=3.53) the Ooglaamie limit would be 9′, about.

mirrors were made to read 500 on the scale. The torsion weight was then removed and the magnet inserted, and the torsion circle turned to read 248° 35′. The movable mirror was next brought to read 500 by means of the screw regulating the distance between the two suspension threads. The angle $z=324° 42' - 248° 35' = 76° 07'$ was calculated to answer the desired value of one division of the scale to represent a variation of the horizontal force of .001 cos θ expressed in metric units, mm., mg., s. By inadvertence, a mistake was made by the observers in their calculation (in the value of H), so that the scale value neither for the horizontal nor for the vertical force corresponds to the value proposed by the president of the Polar Commission. This was not discovered by them until near the close of the observations, when they judged it best to adhere to the old value. The magnetometers were thus given a sensitiveness fully double of what it was intended they should have. The consequence was that many of the largest disturbances in the horizontal and vertical components failed to be registered, the deflections falling beyond the range of the instruments. We have the scale value k in parts of the horizontal force = cot z times 1′ =.00007190, and multiplying by H or 1.939 the scale value becomes .0001394 English units.

(2.) September 18, 1882, 2^h a. m. to 3^h 15^m a. m., Göttingen time, readjusted bifilar instrument. Plane of detorsion read 60° 41′, turned torsion circle to 330° 41′, and movable mirror made to read 50; magnet inserted and torsion circle turned to 254° 34′, movable mirror brought to read 50 by means of the adjusting screw. The angle z equals 76° 07′; hence k or the scale value remains as above. The apparent change in the plane of detorsion of 5° 59′ is due to shift of instrument.

(3.) November 6, 1882, 10^h p. m., to November 7, 2^h 31^m a. m., Göttingen time, readjusted instrument. With plane of detorsion in meridian torsion circle read 52° 46′, adjusted movable mirror to 50, when torsion circle read 322° 46′. Suspended magnet and made torsion circle read 247° 12′, brought movable mirror to 50 by means of adjusting screw. $z=75° 34'$; hence k=.00007487 parts of the horizontal force, and multiplying by H the scale value becomes .0001452 English units.

(4.) February 27, 1883, 3^h 05^m a. m. to 6^h 55^m a. m., Göttingen time, readjusted instrument. Plane of detorsion in magnetic meridian torsion circle reads 52° 35′; movable and fixed mirror adjusted to 50 with torsion circle 322° 35′; suspended magnet and turned circle to 247° 14′, and brought movable mirror again to 50 by means of the adjusting screw. $z=75° 21$; hence k=.00007604 parts of the horizontal force and the scale value .0001474 English units.

(5.) February 28, 1883, 1^h 13^m a. m. to 3^h 37^m a. m., Göttingen time, readjusted instrument. Plane of detorsion in magnetic meridian 40° 22′; turned to 310° 22′ with fixed and movable mirror at 50; suspended magnet, and turned to 235° 01′ with movable mirror at 50 by means of the screw. $z=75° 21'$; hence scale values as in preceding case.

(6.) At 6^h p. m., March 23, Göttingen time, suspended mirror touched fixed mirror owing to stretching of threads; raised suspension at 6^h 45^m p. m.

(7.) At 6^h 45^m a. m., March 25, Göttingen time, suspension further shortened; again at 7^h 10^m p. m. same day.

(8.) At 3 a. m., April 21, Göttingen time, fixed mirror read 486; changed to 500 before taking the 3 a. m. observation.

Increasing scale readings denote increase of horizontal force.

SCALE VALUES.

	English units.	Gaussian units.	B. A. units or dynes.
Value of one division of scale between			
September 11, 1882, and November 6, 1882..	.000139	.0000643	.00000643
November 7, 1882, and February 27, 1883...	.000145	.0000669	.00000669
February 27, 1883, to close of series.........	.000147	.0000680	.00000680
The average scale reading 419 corresponds approximately to horizontal intensity..........	1.939	0.8940	0.08940

[NOTE.—The recapitulation of the monthly mean values of the hourly readings of the Brooke bifilar magnetometer, which is given in the following tables, is deemed sufficient for the purposes of this report; the readings themselves have therefore been omitted.]

The monthly means of the bifilar readings appear quite irregular, produced by large disturbances and by change in adjustment; the latter became necessary in consequence of the effect of temperature and moisture on the suspension. During the winter the observatory became thickly coated with ice on its sides and roof, which, during thawing weather kept the interior atmosphere in a state of extreme moisture; the observed variations in the length of the suspension fibers and in the torsion of the two declination instruments may be thus accounted for, and the greater or less stiffness of the fibers was probably occasioned by moisture deposited upon it, freezing and thawing alternately. The effects on the readings of changes of temperature and gradual loss of magnetism* of the magnet or of secular change, are small compared with the above irregularities from other causes. It would seem desirable to use metallic suspension in the place of silk.

The September mean (619.5) was corrected to 519.1 by application of a rough correction of —318 divisions to the readings of the first six days, found by comparison with the mean of the succeeding six days.

In August, 1883, the mean reading was higher (639.7) than at any other time, and it was evident that the adjustment of the instrument had from some unknown cause been disturbed; one of the observers (Mr. Maxfield) states that when he took down the instrument on the 27th he found the adjusting screw which holds the thread and determines the distance between the threads worked rather loosely in its bearings, whereas it was very tight when the instrument was first set up. It is difficult to fix upon a particular time when the rapid increase in the readings commenced, but it was most probably between August 7 and 8, and lasted for two or three days before the instrument settled again to a fixed condition; a slow progressive motion is apparent from the last days of July. For our present purpose the matter is of little importance, since we shall deal strictly in a differential way, only aiming at roughly comparable absolute readings. In order to reduce the monthly readings during August roughly to a uniform scale a correction of — 187.0 divisions was applied.

* The Brooke magnets are now over thirty years old; they were used at Washington in 1853.

Recapitulation of monthly mean values (inclusive of disturbances and uncorrected for changes of temperature and variations in scale value) of the hourly readings of the Brooke bifilar magnetometer at Ooglaamic, Alaska, 1882–1883.

Göttingen civil time.	0^h.	1^h.	2^h.	3^h.	4^h.	5^h.	6^h.	7^h.	8^h.	9^h.	10^h.	11^h.
† Ooglaamie civil time.	Noon $+53^m.6$	$13^h53^m.6$	$14^h53^m.6$	$15^h53^m.6$	$16^h53^m.6$	$17^h53^m.6$	$18^h53^m.6$	$19^h53^m.6$	$20^h53^m.6$	$21^h53^m.6$	$22^h53^m.6$	$23^h53^m.6$
1882.												
September 12 to 30.	537.1	532.0	536.1	542.0	563.5	558.8	563.0	538.9	518.8	529.5	501.8	526.6
October.	489.2	494.0	490.0	498.5	504.0	485.8	489.0	438.4	468.6	424.6	390.9	404.9
November.	459.1	481.8	477.0	480.1	508.0	485.3	467.8	455.5	452.0	418.3	402.2	372.7
December.	487.9	500.7	513.3	514.8	525.1	522.2	520.9	515.0	500.8	477.7	459.1	467.6
1883.												
January.	438.1	431.5	441.6	455.0	461.1	461.4	454.4	454.6	449.5	449.4	417.7	372.1
February.	441.0	443.6	434.5	445.2	459.0	473.0	475.3	446.0	397.4	399.3	375.0	365.9
March.	462.5	458.3	481.8	510.7	512.1	510.3	489.7	481.9	419.1	439.1	400.2	375.2
April.	355.5	353.0	364.9	418.7	422.5	410.4	416.9	423.6	411.1	374.8	344.3	336.3
May.	396.8	391 3	408.0	416.4	448.3	457.4	469.0	472.9	452.8	429.1	429.3	388.8
June.	372.1	397.2	405.8	444.3	467.3	470.6	518.5	508.7	496.4	465.7	410.0	381.5
•July.	388.3	425.7	447.0	473.3	478.9	505.7	511.8	505.8	488.7	482.6	445.1	421.6
August 1 to 27, inclusive.	498.5	500.2	508.2	540.5	550.2	560.8	567.1	528.1	541.9	553.1	524.3	506.9

Göttingen civil time.	Noon.	13^h.	14^h.	15^h.	16^h.	17^h.	18^h.	19^h.	20^h.	21^h.	22^h.	23^h.	Mean.
Ooglaamie civil time.	$0^h53^m.6$	$1^h53^m.6$	$2^h53^m.6$	$3^h53^m.6$	$4^h53^m.6$	$5^h53^m.6$	$6^h53^m.6$	$7^h53^m.6$	$8^h53^m.6$	$9^h53^m.6$	$10^h53^m.6$	$11^h53^m.6$	
1882.													d.
September.	504.4	508.4	500.4	487.4	498.9	480.4	481.1	496.9	513.6	509.5	500.9	529.1	519.1
October.	401.1	442.1	405.9	406.1	420.3	396.4	390.5	354.4	377.5	419.5	441.5	474.8	437.8
November.	396.3	368.7	340.7	335.9	335.5	349.4	284.6	322.7	342.4	388.3	431.2	439.7	408.1
December.	446.5	397.2	403.5	389.5	417.9	402.7	398.8	427.0	398.5	422.6	459.8	479.8	460.4
1883.													
January.	383.3	370.8	336.4	335.1	339.8	319.8	356.9	328.5	319.0	365.7	400.4	425.7	398.7
February.	388.2	337.0	318.9	349.8	299.3	305.4	289.8	312.7	344.1	330.6	362.6	401.9	382.1
March.	372.4	383.2	326.7	346.9	341.0	313.5	329.2	318.0	345.4	357.4	411.3	441.4	409.5
April.	311.0	290.8	294.9	299.4	303.9	276.1	274.6	245.1	289.0	310.3	329.4	339.9	341.5
May.	341.8	315.0	319.9	317.6	308.9	289.3	269.2	300.7	332.8	357.0	356.0	379.5	377.0
June.	406.3	380.6	329.7	337.6	325.9	258.2	253.8	299.2	284.3	348.3	353.6	374.5	387.1
July.	395.7	387.0	396.4	398.1	341.7	320.3	289.1	274.3	308.0	360.5	386.0	379.8	408.8
August.	519.5	513.9	496.2	472.8	473.4	461.2	441.2	450.4	445.5	435.6	466.0	484.5	501.2
												Mean	419.4

***Solar diurnal variation** of the horizontal force (inclusive of disturbances), expressed in scale divisions and uncorrected for changes in temperature,* 1882–'83.

Göttingen civil time.	k Scale value in parts of force 0.0000	0^h.	1^h.	2^h.	3^h.	4^h.	5^h.	6^h.	7^h.	8^h.	9^h.	10^h.	11^h.
Ooglaamie civil time.		Noon+53^m.6	13^{h}53^m.6	14^{h}53^m.6	15^{h}53^m.6	16^{h}53^m.6	17^{h}53^m.6	18^{h}53^m.6	19^{h}53^m.6	20^{h}53^m.6	21^{h}53^m.6	22^{h}53^m.6	23^{h}53^m.6
1882.													
September.	719	+18.0	+12.9	+17.0	+ 22.9	+ 44.4	+ 39.7	+ 43.9	+ 19.8	− 0.3	+10.4	−17.3	+ 7.5
October.	719	+51.4	+56.2	+52.2	+ 60.7	+ 66.2	+ 48.0	+ 51.2	+ 0.6	+ 30.8	−13.2	−46.9	−32.9
November.	743	+51.0	+73.7	+68.9	+ 72.0	+ 99.9	+ 77.2	+ 59.7	+ 47.4	+ 43.9	+10.2	− 5.9	−35.4
December.	749	+27.5	+40.3	+52.9	+ 54.4	+ 64.7	+ 61.8	+ 60.5	+ 54.6	+ 40.4	+17.3	− 1.3	+ 7.2
1883.													
January.	749	+39.4	+32.8	+42.9	+ 56.3	+ 62.4	+ 62.7	+ 55.7	+ 55.9	+ 50.8	+56.7	+19.0	−26.6
February.	749	+57.9	+60.5	+51.4	+ 62.1	+ 75.9	+ 89.9	+ 92.2	+ 62.9	+ 14.3	+16.2	− 8.1	−17.2
March.	760	+53.0	+48.8	+72.3	+101.2	+102.6	+100.8	+ 80.2	+ 72.4	+ 9.6	+29.6	− 9.3	−34.3
April.	760	+14.0	+11.5	+23.4	+ 77.2	+ 81.0	+ 68.9	+ 75.4	+ 82.1	+ 69.6	+33.3	+ 2.8	− 5.2
May.	760	+19.8	+14.3	+31.0	+ 39.4	+ 71.3	+ 80.4	+ 92.0	+ 95.9	+ 75.8	+52.1	+52.3	+11.8
June.	760	−15.0	+10.1	+18.7	+ 57.2	+ 80.2	+ 83.5	+131.4	+121.6	+109.3	+78.6	+22.9	− 5.6
July.	760	−20.5	+16.9	+38.2	+ 64.5	+ 70.1	+ 96.9	+103.0	+ 97.0	+ 79.9	+73.8	+36.3	+12.8
August.	760	− 2.7	− 1.0	+ 7.0	+ 39.3	+ 49.0	+ 59.6	+ 55.9	+ 26.9	+ 40.7	+51.9	+23.1	+ 5.7
April–September, inclusive.	753	+ 2.3	+10.8	+22.6	+50.1	+66.0	+71.5	+83.6	+73.9	+62.5	+50.0	+20.0	+ 4.5
October–March inclusive.	746	+46.7	+52.1	+56.8	+67.8	+78.6	+73.4	+66.6	+49.0	+31.6	+18.5	− 8.8	−23.2
Year.	750	+24.5	+31.4	+39.7	+58.9	+72.3	+72.5	+75.1	+61.4	+47.1	+34.2	+ 5.6	− 9.4

Göttingen civil time.	k Scale value in parts of force 0.0000	Noon.	13^h.	14^h.	15^h.	16^h.	17^h.	18^h.	19^h.	20^h.	21^h.	22^h.	23^h.
Ooglaamie civil time.		0^{h}53^m.6	1^{h}53^m.6	2^{h}53^m.6	3^{h}53^m.6	4^{h}53^m.6	5^{h}53^m.6	6^{h}53^m.6	7^{h}53^m.6	8^{h}53^m.6	9^{h}53^m.6	10^{h}53^m.6	11^{h}53^m.6
1882.													
September.	719	−14.7	−10.7	−18.7	−31.7	−20.2	− 38.7	− 38.0	− 22.2	− 5.5	− 9.6	−18.2	+10.0
October.	719	−36.7	+ 4.3	−31.9	−31.7	−17.5	− 41.4	− 47.3	− 83.4	− 60.3	−18.3	+ 3.7	+37.0
November.	743	−11.8	−39.4	−67.4	−72.2	−72.6	− 58.7	−123.5	− 85.4	− 65.7	−19.8	+23.1	+31.6
December.	749	−13.9	−63.2	−56.9	−70.9	−42.5	− 57.7	− 61.6	− 33.4	− 61.9	−37.8	− 0.6	+19.4
1883.													
January.	749	−15.4	−27.9	−62.3	−63.6	−58.9	− 78.9	− 41.8	− 70.2	− 79.7	−33.0	+ 1.7	+27.0
February.	749	+ 5.1	−46.1	−64.2	−33.3	−83.8	− 77.7	− 93.3	− 70.4	− 39.0	−52.5	−20.5	+18.2
March.	760	−37.1	−26.3	−82.8	−62.6	−68.5	− 96.0	− 80.3	− 91.5	− 64.1	−52.1	+ 1.8	+31.9
April.	760	−30.5	−50.7	−46.6	−42.1	−37.6	− 65.4	− 66.9	− 96.4	− 52.5	−31.2	−12.1	− 1.6
May.	760	−35.2	−62.0	−57.1	−59.4	−68.1	− 87.7	−107.8	− 76.3	− 44.2	−20.0	−21.0	+ 2.5
June.	760	+19.2	− 6.5	−57.4	−49.5	−61.2	−128.9	−133.3	− 87.9	−102.8	−38.8	−33.5	−12.6
July.	760	−13.1	−21.8	−12.4	−10.7	−67.1	− 88.5	−119.7	−134.5	−100.8	−48.3	−22.8	−29.0
August.	760	+18.3	+12.7	− 5.0	−28.4	−27.8	− 40.0	− 60.0	− 50.8	− 55.7	−65.6	−35.2	−16.7
April–September, inclusive.	753	− 9.3	−23.2	−32.9	−37.0	−47.0	− 74.9	− 87.6	− 78.0	− 60.2	−35.6	−23.8	− 7.9
October–March, inclusive.	746	−18.3	−33.1	−60.9	−55.7	−57.3	− 68.4	− 74.6	− 72.4	− 61.8	−35.6	+ 1.5	+27.5
Year.	750	−13.8	−28.1	−46.9	−46.3	−52.2	− 71.6	− 81.1	− 75.2	− 61.0	−35.6	−11.1	+ 9.8

Monthly mean values of the hourly readings of the thermometer attached to the bifilar magnetometer and expressed in degrees of Fahrenheit's scale.

Göttingen civil time.	0^h.	1^h.	2^h.	3^h.	4^h.	5^h.	6^h.	7^h.	8^h.	9^h.	10^h.	11^h.
Ooglaamie civil time.	N. $+53^m.6$	$13^h+53^m.6$	$14^h+53^m.6$	$15^h+53^m.6$	$16^h+53^m.6$	$17^h+53^m.6$	$18^h+53^m.6$	$19^h+53^m.6$	$20^h+53^m.6$	$21^h+53^m.6$	$22^h+53^m.6$	$23^h+53^m.6$
1882.												
September.	36.4	37.0	37.2	37.1	37.6	36.4	35.9	35.4	34.7	34.5	33.8	33.8
October.	19.6	20.4	20.9	20.8	21.0	20.3	20.0	19.4	18.3	17.5	17.0	17.0
November.	3.8	3.9	4.1	4.2	4.6	4.3	4.5	3.5	2.5	1.9	1.5	1.3
December.	−7.8	−7.5	−7.1	−7.0	−6.4	−6.5	−6.6	−6.8	−7.9	−8.5	−8.9	−9.0
1883.												
January.	−5.3	−4.8	−4.5	−4.7	−4.5	−4.4	−4.4	−4.4	−5.7	−6.4	−6.9	−7.3
February.	3.7	5.1	5.5	5.4	5.9	6.1	6.1	6.0	4.5	3.7	3.1	2.5
March.	2.6	3.5	4.2	4.6	5.9	5.4	4.7	3.9	2.8	2.0	1.0	0.3
April.	15.5	16.3	17.2	17.0	18.0	17.6	17.1	15.8	14.2	12.8	11.5	10.0
May.	37.0	37.3	38.0	37.0	37.0	36.6	35.6	34.5	33.1	31.9	30.7	29.5
June.	47.8	48.1	48.7	48.5	48.0	47.6	46.6	44.8	43.9	42.8	41.8	40.9
July.	49.1	49.5	50.0	49.6	49.4	48.8	48.1	46.5	46.0	45.1	44.1	43.2
August.	47.7	48.3	48.6	48.4	48.5	48.4	48.0	47.2	46.3	45.4	44.8	44.3
April–September, inclusive.	38.9	39.4	40.0	39.6	39.8	39.2	38.6	37.4	36.4	35.4	34.4	33.6
October–March, inclusive.	2.8	3.4	3.8	3.9	4.4	4.2	4.0	3.6	2.4	1.7	1.1	0.8
Whole year.	20.8	21.4	21.9	21.8	22.1	21.7	21.3	20.5	19.4	18.6	17.8	17.2

Göttingen civil time.	Noon.	13^h.	14^h.	15^h.	16^h.	17^h.	18^h.	19^h.	20^h.	21^h.	22^h.	23^h.	Monthly mean.
Ooglaamie civil time.	$0^h+53^m.6$	$1^h+53^m.6$	$2^h+53^m.6$	$3^h+53^m.6$	$4^h+53^m.6$	$5^h+53^m.6$	$6^h+53^m.6$	$7^h+53^m.6$	$8^h+53^m.6$	$9^h+53^m.6$	$10^h+53^m.6$	$11^h+53^m.6$	
1882.													°
September.	34.1	34.0	34.0	33.7	33.9	33.8	33.9	33.9	34.4	34.9	35.3	35.8	+35.1
October.	17.2	17.3	17.3	17.1	17.4	17.5	17.6	17.5	17.4	17.5	17.7	18.4	+18.4
November.	1.6	1.5	1.5	1.5	1.5	1.7	2.3	2.3	2.3	2.5	2.6	2.9	+ 2.7
December.	−8.9	−9.0	−9.0	−9.0	−8.8	−8.7	−7.5	−7.9	−8.0	−8.1	−8.1	−8.2	−8.0
1883.													
January.	−7.1	−7.1	−6.9	−7.0	−6.6	−6.4	−5.4	−5.6	−5.7	−5.7	−5.8	−5.4	−5.8
February.	2.5	2.3	2.2	2.0	2.2	2.2	3.0	2.6	2.5	2.8	3.5	4.0	+ 3.7
March.	−0.1	−0.5	−0.9	−1.2	−1.4	−1.5	−0.9	−0.9	−0.6	0.0	0.9	2.1	+ 1.5
April.	8.9	8.2	7.3	6.8	6.6	6.7	7.6	8.0	9.5	11.0	12.8	14.5	+12.1
May.	28.8	28.2	27.6	27.7	28.2	29.0	29.8	31.1	32.4	33.8	35.5	37.3	+32.8
June.	40.3	39.8	39.6	39.4	39.4	39.8	40.6	41.6	42.7	44.0	45.4	47.0	+43.7
July.	43.0	42.6	42.2	42.4	42.3	42.5	43.3	43.9	45.0	46.1	47.4	48.4	+45.8
August.	44.0	43.3	43.1	42.9	42.7	42.5	42.8	43.1	43.8	44.7	45.9	47.1	+45.5
April–September, inclusive.	33.2	32.7	32.3	32.2	32.2	32.4	33.0	33.6	34.6	35.8	37.0	38.4	+35.8
October–March, inclusive.	0.9	0.8	0.7	0.6	0.7	0.8	1.5	1.3	1.3	1.5	1.8	2.3	+ 2.1
Whole year.	17.0	16.7	16.5	16.4	16.4	16.6	17.3	17.5	18.0	18.6	19.4	20.3	+19.0

Temperature coefficient.—There were no special observations made to ascertain the effect of changes of temperature on the magnetic moment of the bifilar magnet; the instrument was mechanically compensated as near as could be judged; we have therefore to determine the outstanding effect by means of the ordinary hourly readings. During 1882 one lamp was continuously burning in the observatory, but early next year three lamps were kept burning, the supply of oil being greater than was at first supposed. The annual average temperature in the observatory, as shown by a Fahrenheit thermometer inside the zinc cover of the bifilar, was $+19^{\circ}.0$ or $-7^{\circ}.22$ C.

In consequence of the irregularities in the state of the instrument, as shown by the monthly mean readings, the only available method for deducing the temperature coefficient q appeared to be that of selecting a number of consecutive and undisturbed days at times when the temperature

was rapidly changing, and finding for each case the apparent change of the daily means in scale divisions corresponding to a change of 1° in temperature. The following values were thus found:

Date.	Change.	Corresponding change.	Change for 1° Fah.
1882.	*d.*	°	*d.*
Oct. 30–31	+ 55	+ 13.4	+ 4.1
Nov. 10–11	+ 26	− 8.0	− 3.3
Dec. 1– 2	+ 27	− 7.3	− 3.7
Dec. 14–15	− 39	+ 11.0	− 3.5
Dec. 15–16	+ 44	− 10.3	− 4.3
1883.			
Feb. 9–10	+ 40	− 7.4	− 5.3
Mar. 11–12	+ 16	+ 6.8	+ 2.4
July 19–20	+ 37	− 8.3	− 4.5

It is proposed to adopt provisionally the mean value — 2.2 ± 0.8, which is equivalent to a *decrease* of 0.000165 parts of the horizontal force for an *increase* of temperature of 1° Fah. or $q = 0.000165$

In the following table the values in column 3, 4, 5 are uncorrected for changes of temperature; the next three columns show the temperature differences for which corrections were required, and the last three columns give the diurnal variations thus corrected. They are laid down on the accompanying diagram.

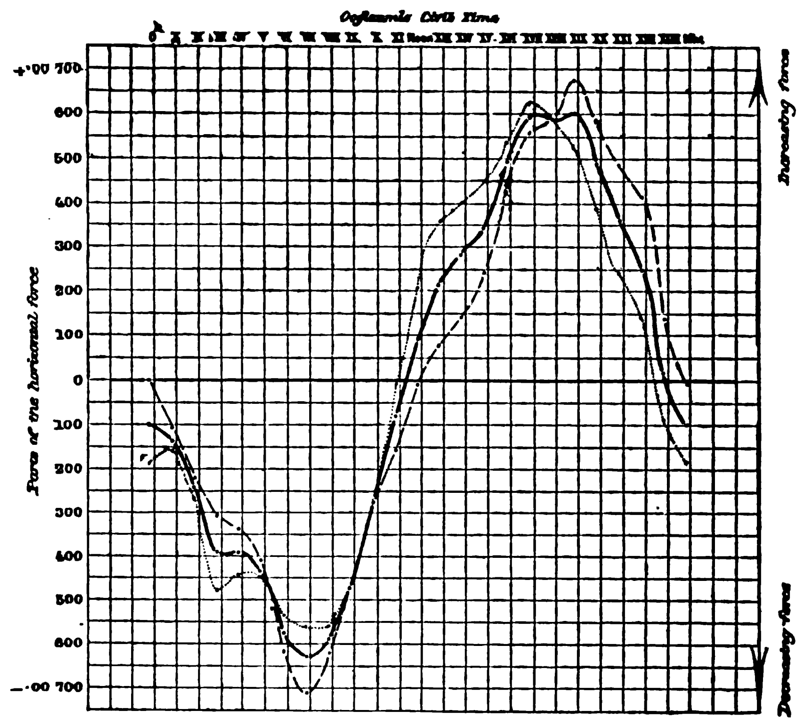
***Solar-diurnal variation** of the horizontal force, inclusive of disturbances, and expressed in parts of the force, Ooglaamie,* 1882–'83.

Göttingen civil time.	Ooglaamie civil time.	Six months, sun north of equator.	Six months, sun south of equator.	Whole year.	Temperature difference.			Solar diurnal variation.		
					$t-35°.8$ ⊙ n.	$t-2°.1$ ⊙ s.	$t-19°.0$ year.	Half year, sun north of equator.	Half year, sun south of equator.	Whole year.
h.	*h. m.*				°	°	°			
0	Noon+53.6	+.00017	+.00348	+.00184	+3.1	+0.7	+1.8	+.00069	+.00360	+.00214
1	13+53.6	081	389	236	+3.6	+1.3	+2.4	140	410	276
2	14+53.6	170	424	298	+4.2	+1.7	+2.9	239	452	346
3	15+53.6	377	506	442	+3.8	+1.8	+2.8	440	536	488
4	16+53.6	497	586	542	+4.0	+2.3	+3.1	563	624	593
5	17+53.6	538	548	544	+3.4	+2.1	+2.7	594	583	589
6	18+53.6	630	497	563	+2.8	+1.9	+2.3	676	528	601
7	19+53.6	556	366	461	+1.6	+1.5	+1.5	582	391	486
8	20+53.6	471	236	353	+0.6	+0.3	+0.4	481	241	360
9	21+53.6	376	+ 138	257	−0.4	−0.4	−0.4	369	+ 131	250
10	22+53.6	151	− 065	+ 042	−1.4	−1.0	−1.2	+ 128	− 081	+ 022
11	23+53.6	+ 034	173	− 071	−2.2	−1.3	−1.8	− 002	194	− 101
Noon	0+53.6	− 070	136	103	−2.6	−1.2	−2.0	113	156	136
13	1+53.6	175	247	211	−3.1	−1.3	−2.3	226	268	249
14	2+53.6	248	454	352	−3.5	−1.4	−2.5	306	477	393
15	3+53.6	279	416	347	−3.6	−1.5	−2.6	338	441	390
16	4+53.6	354	427	391	−3.6	−1.4	−2.6	413	450	434
17	5+53.6	564	510	537	−3.4	−1.3	−2.4	620	531	577
18	6+53.6	660	557	608	−2.8	−0.6	−1.7	706	567	636
19	7+53.6	587	540	564	−2.2	−0.8	−1.5	623	553	589
20	8+53.6	453	461	458	−1.2	−0.8	−1.0	473	474	474
21	9+53.6	268	− 266	267	0.0	−0.6	−0.4	268	− 276	274
22	10+53.6	179	+ 011	− 083	+1.2	−0.3	+0.4	159	+ 006	− 076
23	11+53.6	− 059	+ 205	+ 073	+2.6	+0.2	+1.3	− 016	+ 208	+ 094

SOLAR-DIURNAL VARIATION OF THE MAGNETIC HORIZONTAL FORCE

Observed at Ooglaamie, Alaska

([illegible])



Full curve ——— mean of the year, Sept. 1882, to Aug. 1883, incl.
Broken - — — — mean of 6 months, sun in north declination.
Dotted - ········ mean of 6 months, sun in south declination.

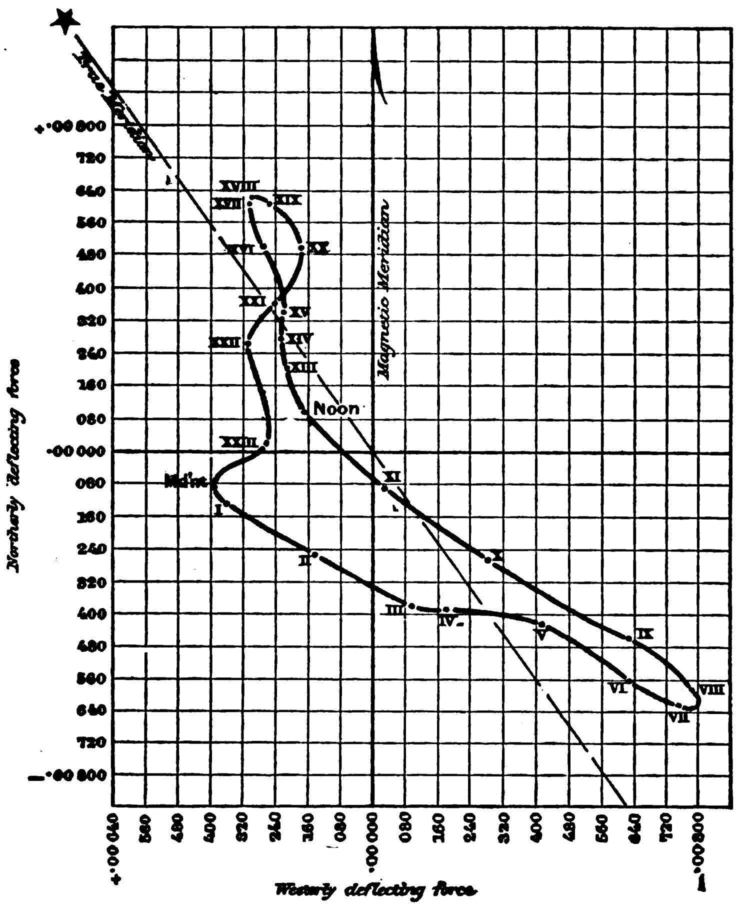
At Ooglaamie the daily maximum value of the horizontal force occurs between the hours 5 and 7 p. m., and the daily minimum about 7 a. m.; there is also a very slight indication of a secondary disturbance in the regular progression between 3 and 5 a. m., corresponding probably to a secondary maximum about 6 a. m., as exhibited at Toronto, and more strongly at Philadelphia at $5\frac{3}{4}$ a. m., where it constitutes the principal maximum, the secondary occurring at 4 p. m. The maximum at Toronto takes place between 4 and 5 p. m., and the minimum about 10 a. m.

The diurnal inequality in the whole deflecting force acting in the horizontal plane may be exhibited graphically both in direction and magnitude as in the annexed diagram.

The origin of the co-ordinates represents the normal declination and horizontal force, and any line drawn from it to any part of the curve will represent its direction and magnitude (according to scale of diagram), the deflecting force acting at the time marked against that point. If for any time the angle ψ equals the westerly deflection of the horizontal needle, the deflecting force producing the same is H sin ψ, and when expressed in parts of the horizontal force, simply sin ψ. A deflection of ψ minutes corresponds to $\frac{\psi}{3437.7}$ or 0.000291 ψ parts nearly. The table of the solar diurnal variation of the declination contains the values of ψ for every hour of the day, and the corresponding change in the force at right angles thereto is contained in the preceding table of the variations of the horizontal force; these two components, the westerly and northerly, appear combined in the diagram. It will be seen that the disturbing forces act more energetically in a plane approaching closer to the true than to the magnetic meridian, and that the usual character of the representation is changed by their action, that half of the curve containing the hours 21 (9 p. m.) to $2\frac{1}{2}$ a. m. being thrown far to the westward, forming a loop, and beyond the branch containing noon; on the other hand the great extension of the deflecting force between 7 and 8 a. m. is wholly due to the great activity of the *easterly* disturbances about these hours. This will become clear when the disturbances have been separated from the normal deflecting forces, and a diagram for the latter alone is presented.

Diurnal variation in the whole deflecting force acting in the horizontal plane.

[The intensity of the whole horizontal deflecting force is expressed in parts of H and all disturbances are included.]



THE VERTICAL FORCE MAGNETOMETER.

The length of one division of the scale is 1 millimeter; the radius mirror to scale is 1.719 meters, hence angular value of one division of scale = 1′. In consequence of the great sensitiveness given to the instrument, which was nearly double of what it was intended it should have, a few of the largest disturbances during November were beyond the range of the instrument and thus failed to be recorded.

(1.) Adjustment and determination of scale value September 9, 1882, noon. The knife-edge was brought into the magnetic meridian on the leveled agate supports, the magnet was balanced, and at 11h 22m p. m., Göttingen time, the fixed and movable mirrors were made to read 500.

Observations for time of one oscillation of magnet and appendages.

MAGNET SUPPORTED ON KNIFE-EDGE.

Number of oscillations.*	Time.
	m. s.
10	2 18.0
16	3 25.5
16	3 28.0
16	3 33.5
58	12 45.0

* By chronometer Bond 188.

MAGNET SUSPENDED BY THREADS.

Number of oscillations.*	Time.
	m. s.
8	2 21.5
10	2 56.9
10	2 56.2
28	8 14.6

* By chronometer Bond 188.

Hence $T_{,} = 17^{s}.664$ (uncorrected for torsion).

Hence $T = 13^s.190$, and value of one division of the scale in parts of the vertical force (for $\log \psi = \log 1'$).

$$\frac{T_{,}^{2}\left(1 + \frac{h}{f}\right)}{T^{2}} \cot \theta \,.\, \psi = 0.00008028$$

And multiplying by $V = 12.786$, value of one division of scale $= 0.001026$ (English units).

OBSERVATIONS FOR TORSION OF THREAD.

Torsion circle.	Scale extremes.		Mean.	Diff.
°	d.	d.	d.	d.
15	488 and	711	600	84
285	708	323	516	174
105	625	754	690	93
15	480	714	597	

Value of one division $= 1'$; $351 \div 4 = 87'.8$; hence corrected time $T_{,} = 17^s.664 \sqrt{1 + \frac{h}{f}}$ $= 17^s.807$

(2.) Readjustment November 3, $10\frac{1}{2}^h$ p. m. (Göttingen time), to November 4, $4\frac{1}{2}^h$ a. m. (Göttingen time). Instrument releveled, fixed mirror made to read 500; also movable mirror adjusted to division 50, $5^h\ 20^m$ p. m. (local time).

Observations for time of one oscillation of magnet and appendages.

MAGNET SUPPORTED ON KNIFE-EDGE.

The center of gravity was raised until time of one oscillation was found to be $T = 13^s.698$; after a few minutes the operation was repeated with the following result:

Number of oscillations.*	Time.
	m. s.
10	2 07.5
8	1 42.0
18	3 49.5

* By chronometer Bond 188.

Hence $T = 12^s.750$, mean $T = 13^s.224$ and value of one division of the scale in parts of the vertical force $= 0.00008163$ which is equal to 0.001044 English units.

MAGNET SUSPENDED BY THREADS.

Number of oscillations.*	Time.
	m. s.
10	2 57.8
10	2 59.0
20	5 56.8

* By chronometer Bond 188.

Hence $T_{,} = 17^s.840$ (uncorrected for torsion).

OBSERVATION FOR TORSION OF THREAD.

Torsion circle.	Scale extremes.		Mean.	Diff.
°	d.	d.	d.	d.
164	596 and	693	644	84
74	523	596	560	204
254	755	773	764	108
164	613	699	656	
				$396 \div 4 = 99'.0$

Hence $T_{,} = 18^s.002$

(3.) Balance magnetometer adjusted Novmber 14, 1882, 7^h p. m., Göttingen time, so as to oscillate in $9^s.060$ and to read 500 at $10^h\ 05^m$ p. m. (Göttingen time). This value for T was derived from 20 oscillations; no particulars are recorded. No observations of oscillations with magnet suspended. With $T_{,} = 18^s.002$ and $T = 9^s.060$ we have scale value in parts of the vertical force 0.0001739 which is equal to 0.002223 English units.

(4.) Readjustment of balance magnetometer March 4, 1883. Instrument leveled with supporting edge in magnetic prime vertical 7^h a. m., Göttingen time; magnet balanced by means of weights and both mirrors brought to scale 50 (8^h a. m., Göttingen time); magnet brought to oscillate in $11^s.850$ by means of adjusting weight on upright stem ($8\frac{1}{2}$ a. m., Göttingen time).

Number of oscillations.*	Time.
	m. s.
10	1 58.5
10	1 58.5
20	3 57.0

*By chronometer Bond 188.

Hence T=11ˢ.850

With $T_{\prime}$=18ˢ.002 and T=11ˢ.850 we have value of one division of scale in parts of the vertical force 0.0001017, which equals 0.001300 English units.

(5.) March 29, 1883, about 4^h a. m. Göttingen time, magnet removed, cleaned of slight frost that had collected on it, and replaced between 4 and 5 p. m.

(6.) April 15, 1883, magnet raised from support and lowered between 6^h 55^m and 7^h 00^m p. m., Göttingen time.

(7.) Readjustment of the balance magnetometer April 27, 1883; instrument leveled. Supporting edge in magnetic meridian for oscillations in horizontal plane at 2^h 12^m a. m. Göttingen time. Between 4^h 10^m and 5^h 40^m a. m., adjusted fixed and movable mirrors to scale division 50.

Number of oscillations.	Time by Bond 188.
	h. m. s.
0	1 16 55.0
6	17 42.5
13	18 37.0
19	19 23.5

Time of one oscillation = 7ˢ.816

Number of oscillations.	Time by Bond 188.
	h. m. s.
0	2 27 03.5
6	28 52.0
13	30 59.5
19	32 47.5

Time of one oscillation = 18ˢ.105

Number of oscillations.	Time by Bond 188.
	h. m. s.
0	6 38 29.0
6	39 15.0
13	40 02.5
19	40 41.5

Time of one oscillation = 6ˢ.974

TORSION CIRCLE.

Change.	Scale extremes.		Mean.	Diff.
°	d.	d.	d.	d.
	250 and	690	470	
90	15	735	375	95
180	460	730	595	220
90	235	675	455	140
				455:4=113′.8

Hence $T_{\prime}$=18ˢ.295

Hence scale value for the time preceding April 27, using T=7ˢ.816, one division=0.0002413 parts of the vertical force or 0.003086 English units, and after April 27 using T=6ˢ.974, one division=0.0003031 parts of the force or 0.003876 English units.

(8.) May 3, 1883, magnet of balance magnetometer raised on support and lowered between 11 and 12 p. m. (Göttingen time). Found time of one oscillation in the vertical plane=8ˢ.750, hence with $T_{\prime}$=18ˢ.295 one division of the scale = 0.0001926 parts of the vertical force or 0.002462 English units.

(9.) May 21, 1883, at 3 a. m., Göttingen time, magnet fell off support; replaced it, and determined time of one oscillation 8ˢ.700; hence one division of scale=0.0001948 parts of the vertical force or 0.002490 English units.

Increasing scale readings denote increasing vertical force.

[NOTE.—It having been deemed advisable, for the purposes of this report, to omit the hourly readings of the Brooke magnetometer and to give only their monthly mean values, these values will be found in the tables following:]

SCALE VALUES.

	English units.	Gaussian units.	B. A. units or dynes.
Value of one division of scale between			
September 9, 1882, and November 3, 1882.	.00103	.000473	.000047
November 3, 1882, and November 14, 1882.	.00104	.000481	.000048
November 14, 1882, and March 4, 1883.	.00222	.00102	.000102
March 4, 1883, and April 15, 1883.	.00130	.00060	.000060
April 15, 1883, and April 27, 1883.	.00309	.00142	.000142
April 27, 1883, and May 3, 1883.	.00388	.00179	.000179
May 3, 1883, and May 21, 1883.	.00246	.00114	.000114
May 21, 1883, to close of series.	.00249	.00115	.000115
The average scale reading 523 corresponds approximately to vertical intensity.	12.792	5.898	0.5898

Recapitulation of monthly mean values (inclusive of disturbances and uncorrected for changes of temperature and variations in scale value) of the hourly readings of the balance magnetometer a Ooglaamie, Alaska, 1882–'83.

Göttingen civil time.	0^h.	1^h.	2^h.	3^h.	4^h.	5^h.	6^h.	7^h.	8^h.	9^h.	10^h.	11^h.
Ooglaamie civil time.	Noon $+53^m.6$	$13^h53^m.6$	$14^h53^m.6$	$15^h53^m.6$	$16^h53^m.6$	$17^h53^m.6$	$18^h53^m.6$	$19^h53^m.6$	$20^h53^m.6$	$21^h53^m.6$	$22^h53^m.6$	$23^h53^m.6$
1882.												
September 12 to 30.	517.3	516.0	516.6	516.8	514.9	513.9	515.1	514.4	513.3	512.3	514.0	515.5
October.	517.7	517.1	517.2	516.3	515.3	513.7	512.3	409.6	511.4	513.0	517.7	518.6
November.	512.2	512.5	511.5	509.2	507.6	506.8	507.2	504.6	504.9	514.9	515.2	521.7
December.	523.0	523.2	523.3	522.5	521.5	521.2	521.9	519.9	516.2	517.5	520.1	520.4
1883.												
January.	511.5	512.7	513.5	513.6	512.9	512.7	511.7	511.0	510.6	509.8	509.1	508.5
February.	503.2	504.0	502.8	501.7	502.0	500.4	498.9	498.4	496.9	497.6	498.2	498.3
March.	519.5	518.3	517.6	515.3	515.6	514.0	512.4	507.8	506.4	508.0	509.9	514.4
April.	509.6	509.4	508.9	507.6	506.7	505.8	505.3	506.4	506.9	507.4	509.0	510.7
May.	514.5	514.2	514.0	514.8	514.7	513.5	513.5	512.5	511.8	512.4	513.2	514.8
June.	528.4	528.3	528.6	528.1	527.3	527.8	527.1	524.9	525.5	527.1	529.7	530.6
July.	546.5	545.9	544.1	542.6	542.0	542.8	542.9	543.5	543.2	542.8	544.0	546.6
August 1 to 27, inclusive.	549.0	548.1	547.7	547.8	547.3	547.2	546.3	546.0	546.4	546.9	547.1	548.4

Göttingen civil time.	Noon.	13^h.	14^h.	15^h.	16^h.	17^h.	18^h.	19^h.	20^h.	21^h.	22^h.	23^h.	Mean.
Ooglaamie civil time.	$0^h53^m.6$	$1^h53^m.6$	$2^h53^m.6$	$3^h53^m.6$	$4^h53^m.6$	$5^h53^m.6$	$6^h53^m.6$	$7^h53^m.6$	$8^h53^m.6$	$9^h53^m.6$	$10^h53^m.6$	$11^h53^m.6$	
1882.													d.
September.	519.4	520.7	521.2	522.1	524.0	524.2	522.0	520.0	517.8	516.9	516.6	517.0	517.6
October.	524.0	526.8	528.9	529.2	529.9	529.5	525.6	522.8	524.7	520.0	519.0	518.5	520.0
November.	524.3	526.2	540.1	544.7	547.2	552.9	540.7	534.9	536.0	523.5	530.5	515.8	532.7
December.	525.2	527.6	529.6	530.6	529.4	530.4	529.3	526.1	523.9	523.1	521.5	522.3	523.7
1883.													
January.	510.3	513.0	517.4	519.9	519.3	518.5	517.9	516.2	514.4	511.5	510.2	510.6	513.2
February.	501.6	505.9	509.4	511.7	514.4	513.8	513.5	512.3	507.4	504.3	504.5	502.3	504.3
March.	522.2	527.8	530.4	532.1	534.7	534.3	532.4	528.5	523.4	520.1	519.9	518.9	520.2
April.	513.3	515.8	518.3	519.6	520.5	521.6	521.5	520.6	518.3	516.5	515.3	513.5	512.9
May.	518.7	521.3	523.7	526.6	526.3	525.6	523.7	520.5	517.5	515.6	514.8	513.8	517.2
June.	532.8	534.0	535.7	537.6	538.8	539.8	538.7	535.6	531.9	529.6	528.5	528.0	531.0
July.	549.5	550.5	552.7	553.7	555.5	556.8	556.7	555.0	552.9	550.2	548.2	547.1	548.2
August.	549.1	551.2	552.2	554.0	554.8	554.4	554.0	553.0	551.2	549.9	549.1	549.3	549.6

Solar-diurnal variation of the vertical force (inclusive of disturbances), expressed in scale divisions and uncorrected for changes of temperature, 1882–'83.

Göttingen civil time.	k or scale value in parts of force 0.000	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
Ooglaamie civil time.		Noon+53m.6	13h53m.6	14h53m.6	15h53m.6	16h53m.6	17h53m.6	18h53m.6	19h53m.6	20h53m.6	21h53m.6	22h53m.6	23h53m.6
1882.													
September.	0803	− 0.3	− 1.6	− 1.0	− 0.8	− 2.7	− 3.7	− 2.5	− 3.2	− 4.3	− 5.3	− 3.6	− 2.1
October.	0803	− 2.3	− 2.9	− 2.8	− 3.7	− 4.7	− 6.3	− 7.7	−10.4	− 8.6	− 7.0	− 2.3	− 1.4
November.	1307	−10.5	−10.2	−11.2	−13.5	−15.1	−15.9	−15.5	−18.1	−17.8	− 7.8	− 7.5	− 1.0
December.	1739	− 0.7	− 0.5	− 0.4	− 1.2	− 2.2	− 2.5	− 1.8	− 3.8	− 7.5	− 6.2	− 3.6	− 3.3
1883.													
January.	1739	− 1.7	− 0.5	+ 0.3	+ 0.4	− 0.3	− 0.5	− 1.5	− 2.2	− 2.6	− 3.4	− 4.1	− 4.7
February.	1739	− 1.1	− 0.3	− 1.5	− 2.6	− 2.3	− 3.9	− 5.4	− 5.9	− 7.4	− 6.7	− 6.1	− 6.0
March.	1087	− 0.7	− 1.9	− 2.6	− 4.9	− 4.6	− 6.2	− 7.8	−12.4	−13.8	−12.2	−10.3	− 5.8
April.	1844	− 3.3	− 3.5	− 4.0	− 5.3	− 6.2	− 7.1	− 7.6	− 6.5	− 6.0	− 5.5	− 3.9	− 2.2
May.	2031	− 2.7	− 3.0	− 3.2	− 2.4	− 2.5	− 3.7	− 3.7	− 4.7	− 5.4	− 4.8	− 4.0	− 2.4
June.	1948	− 3.4	− 3.3	− 2.4	− 2.9	− 3.7	− 3.2	− 3.9	− 6.1	− 5.5	− 3.9	− 1.3	− 0.4
July.	1948	− 1.7	− 2.3	− 4.1	− 5.6	− 6.2	− 5.4	− 5.3	− 4.7	− 5.0	− 5.4	− 4.2	− 1.6
August.	1948	− 0.6	− 1.5	− 1.9	− 1.8	− 2.6	− 2.4	− 3.3	− 3.6	− 3.2	− 2.7	− 2.5	− 1.2
April to September, inclusive.	1754	− 2.0	− 2.5	− 2.8	− 3.1	− 4.0	− 4.2	− 4.4	− 4.8	− 4.9	− 4.6	− 3.2	− 1.6
October to March, inclusive.	1402	− 2.8	− 2.7	− 3.0	− 4.2	− 4.9	− 5.9	− 6.6	− 8.8	− 9.6	− 7.2	− 5.6	− 3.7
Year.	1578	− 2.4	− 2.6	− 2.9	− 3.7	− 4.4	− 5.1	− 5.5	− 6.8	− 7.3	− 5.9	− 4.4	− 2.7

Göttingen civil time.	k or scale value in parts of force 0.000	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
Ooglaamie civil time.		0h53m.6	1h53m.6	2h53m.6	3h53m.6	4h53m.6	5h53m.6	6h53m.6	7h53m.6	8h53m.6	9h53m.6	10h53m.6	11h53m.6
1882.													
September.	0803	+1.8	+3.1	+ 3.6	+ 4.5	+ 6.4	+ 6.6	+ 4.4	+ 2.4	+ 0.2	−0.7	−1.0	−0.6
October.	0803	+4.0	+6.8	+ 8.9	+ 9.2	+ 9.9	+ 9.5	+ 5.6	+ 2.8	+ 4.7	0.0	−1.0	−1.5
November.	1307	+1.6	+3.5	+17.4	+22.0	+24.5	+30.2	+18.0	+12.2	+13.3	+0.8	+7.8	−6.9
December.	1739	+1.5	+3.9	+ 5.9	+ 6.9	+ 5.7	+ 6.7	+ 5.6	+ 2.4	+ 0.2	−0.6	−2.2	−1.4
1883.													
January.	1739	−2.9	−0.2	+ 4.2	+ 6.7	+ 6.1	+ 5.3	+ 4.7	+ 3.0	+ 1.2	−1.7	−3.0	−2.6
February.	1739	−2.7	+1.6	+ 5.1	+ 7.4	+10.1	+ 9.5	+ 9.2	+ 8.0	+ 3.1	0.0	+0.2	−2.0
March.	1087	+2.0	+7.6	+10.2	+11.9	+14.5	+14.1	+12.2	+ 8.3	+ 3.2	−0.1	−0.3	−1.3
April.	1844	+0.4	+2.9	+ 5.4	+ 6.7	+ 7.6	+ 8.7	+ 8.6	+ 7.7	+ 5.4	+3.6	+2.4	+0.6
May.	2031	+1.5	+4.1	+ 6.5	+ 9.4	+ 9.1	+ 8.4	+ 6.5	+ 3.3	+ 0.3	−1.6	−2.4	−3.4
June.	1948	+1.8	+3.0	+ 4.7	+ 6.6	+ 7.8	+ 8.8	+ 7.7	+ 4.6	+ 0.9	−1.4	−2.5	−3.0
July.	1948	+1.3	+2.3	+ 4.5	+ 5.5	+ 7.3	+ 8.6	+ 8.5	+ 6.8	+ 4.7	+2.0	0.0	−1.1
August.	1948	−0.5	+1.6	+ 2.6	+ 4.4	+ 5.2	+ 4.8	+ 4.4	+ 3.4	+ 1.6	+0.3	−0.5	−0.3
April to September, inclusive.	1754	+1.0	+2.8	+ 4.5	+ 6.2	+ 7.2	+ 7.6	+ 6.7	+ 4.7	+ 2.2	+0.4	−0.7	−1.3
October to March, inclusive	1402	+0.6	+3.9	+ 8.6	+10.7	+11.8	+12.5	+ 9.2	+ 6.1	+ 4.3	−0.3	+ 0.2	−2.6
Year.	1578	+0.8	+3.4	+ 6.6	+ 8.4	+ 9.5	+10.1	+ 8.0	+ 5.4	+ 3.2	+0.1	−0.2	−1.9

Temperature coefficient.—There are no special observations made to determine the effect of change of temperature on the magnetic moment of the balance magnet. The instrument was mechanically compensated as near as could be judged, and there remains only to determine the outstanding effect by means of the ordinary readings. There was no thermometer in the case of the balance magnetometer, but the same temperature table as was given for the bifilar magnetometer answers, since the readings of the two thermometers—one with the unifilar, the other with

the bifilar—rarely differ more than half a degree, and less than 0°.1 Fah. in the monthly means. Applying the same process as in the case of the bifilar we find:

Date.	Change.	Corresponding change.	Change for 1° Fah.
1882.	d.	°	d.
Oct. 14–15	− 11	+ 10.9	− 1.0
30–31	− 17	+ 13.4	− 1.3
Nov. 1–2	+ 14	− 14.2	− 1.0
10–11	+ 17	− 8.0	− 2.1
23–24	− 10	− 7.0	+ 1.4
Dec. 1–2	− 10.5	− 7.3	+ 1.4
14–15	+ 9	+ 11.0	+ 0.8
15–16	− 16	− 10.3	+ 1.5
1883.			
Jan. 1–2	− 13	+ 12.7	− 1.0
22–23	− 7	+ 7.5	− 0.9
Feb. 9–10	+ 5	− 7.4	− 0.7
Mar. 1–2	+ 12	− 12.7	− 0.9
11–12	− 10	+ 6.8	− 1.5
24–25	− 34	+ 12.2	− 2.8
Apr. 19–20	− 11	+ 8.3	− 1.3
July 19–20	+ 9	− 8.3	− 1.1
Aug. 7–8	− 7	+ 8.9	− 0.8
		Mean	− 0.66 ± 0.20

It is proposed to adopt for the present the value $-0^d.7 \pm 0.2$, which is equivalent to a *decrease* of $0.7 \times .0001584$ (or 0.7 times the average value for one division), or .000111 parts of the vertical force for an *increase* of temperature of 1° Fah.

Solar diurnal variation of the vertical force (inclusive of disturbances) expressed in parts of the force, Ooglaamie, 1882–'83.

Göttingen civil time.	Ooglaamie civil time.	Six months, sun north of equator.	Six months, sun south of equator.	Whole year.	Temperature difference.			Solar diurnal variation.		
					$t-35°.8$ ⊙ n.	$t-2°.1$ ⊙ s.	$t-19°.0$ year.	Half year, sun north of equator.	Half year, sun south of equator.	Whole year.
h.	h. m.				°	°	°			
0	Noon+53.6	−.00035	−.00039	−.00038	+3.1	+0.7	+1.8	−.00001	−.00031	−.00018
1	13+53.6	044	038	041	+3.6	+1.3	+2.4	004	024	014
2	14+53.6	049	042	046	+4.2	+1.7	+2.9	002	023	014
3	15+53.6	054	059	058	+3.8	+1.8	+2.8	012	039	027
4	16+53.6	070	069	069	+4.0	+2.3	+3.1	026	043	035
5	17+53.6	074	083	080	+3.4	+2.1	+2.7	036	060	050
6	18+53.6	077	093	087	+2.8	+1.9	+2.3	046	072	061
7	19+53.6	084	123	107	+1.6	+1.5	+1.5	066	106	090
8	20+53.6	086	135	115	+0.6	+0.3	+0.4	079	132	111
9	21+53.6	081	101	093	−0.4	−0.4	−0.4	085	105	097
10	22+53.6	056	079	069	−1.4	−1.0	−1.2	072	090	082
11	23+53.6	− 028	− 052	− 043	−2.2	−1.3	−1.8	052	066	063
Noon	0+53.6	+ 018	+ 008	+ 013	−2.6	−1.2	−2.0	− 011	− 005	− 009
13	1+53.6	049	055	054	−3.1	−1.3	−2.3	+ 015	+ 041	+ 028
14	2+53.6	079	121	104	−3.5	−1.4	−2.5	040	105	076
15	3+53.6	109	150	133	−3.6	−1.5	−2.6	069	133	104
16	4+53.6	126	165	150	−3.6	−1.4	−2.6	086	149	121
17	5+53.6	133	175	159	−3.4	−1.3	−2.4	095	161	132
18	6+53.6	118	129	126	−2.8	−0.6	−1.7	087	122	107
19	7+53.6	082	086	085	−2.2	−0.8	−1.5	058	077	068
20	8+53.6	039	+ 060	050	−1.2	−0.8	−1.0	026	+ 051	+ 039
21	9+53.6	+ 007	− 004	+ 002	0.0	−0.6	−0.4	007	− 011	− 002
22	10+53.6	− 012	+ 003	− 003	+1.2	−0.3	+0.4	001	000	+ 001
23	11+53.6	−.00023	−.00036	−.00030	+2.6	+0.2	+1.3	+.00006	−.00034	−.00016

The numbers contained in the last three columns of this table were plotted on the accompanying diagram, which shows the vertical force to be in excess of its average value in the (local) morning hours, maximum about 6 a. m., and in deficiency in the (local) afternoon hours, minimum about 9 p. m. Compared with the variation of the vertical force at more southern stations there appears to be a complete inversion of the hours of greater and of less intensity, which may be due to the action of disturbances, or, if regular, it may be somehow connected with the circumstance that Ooglaamie is near the central zone of maximum auroral display and a little to the north of it. We note the apparent greater range of the diurnal variation in the half year including the winter than in the other six months, which is also an anomalous phenomenon.

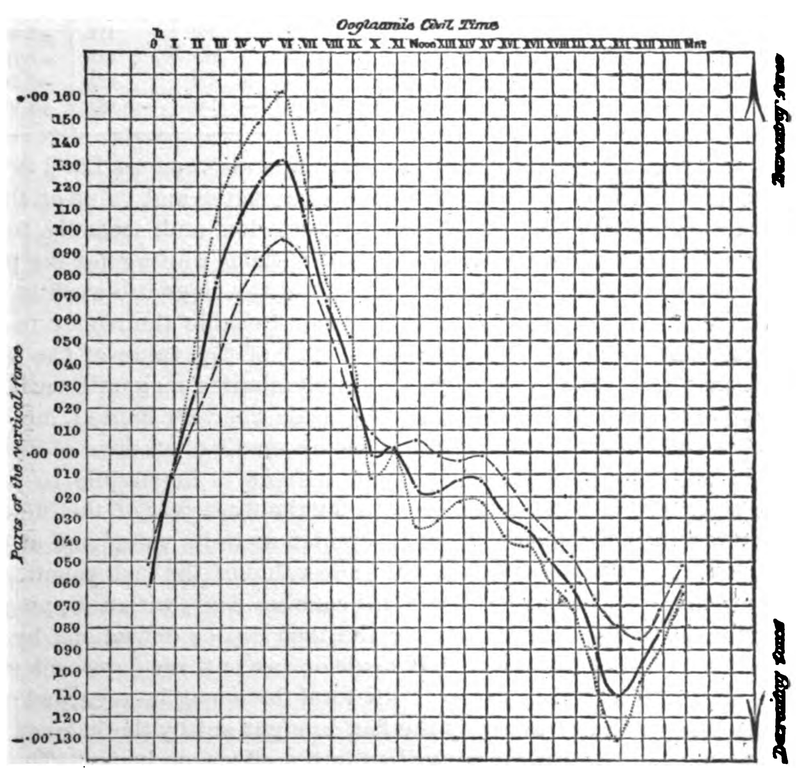
The breakage of the magnetic and electric equilibrium in the vicinity of this auroral zone, resulting in an outburst of disturbances, probably occurs more frequently within this belt than outside of it, and possibly sudden changes of temperature may be favorable circumstances of disruption. The belt of maximum auroral development seems to be subject to fluctuations in position, and in studying the supposed connection of auroras with terrestrial magnetism attention should be directed to the local direction in which the aurora appears at a station, *i. e.*, at Ooglaamie, whether to the south or to the north of the zenith.

The increased dip and total intensity in the Ooglaamie morning hours as contrasted with the diminished dip and intensity of the total force in the afternoon hours is corroborated by the observations made in the first year by means of the dip circle and deflecting weight.

SOLAR DIURNAL VARIATION OF THE MAGNETIC VERTICAL FORCE

Observed at Ooglaamie, Alaska

(DISTURBANCES INCLUDED)



Full curve —— mean of the year Sept. 1882 to Aug. 1883, [illegible]
Broken " —— mean of 6 months [illegible] north [illegible]
Dotted " —— mean of 6 months [illegible] south [illegible]

SOLAR DIURNAL VARIATIONS IN THE MAGNETIC DIP AND IN THE TOTAL MAGNETIC INTENSITY.

These variations are readily obtained from the variations in the horizontal and in the vertical components of the force. If F = total force, H and V its horizontal and vertical components, then from the fundamental relations

$$H = F \cos \theta \qquad\qquad V = F \sin \theta$$

we find by differentiation and elimination the variation in the dip $\triangle \theta$ and the variation in the total force (in parts of the force) $\frac{\triangle F}{F}$, viz:

$$\triangle \theta = \sin \theta \cos \theta \left(\frac{\triangle V}{V} - \frac{\triangle H}{H} \right) \text{ and } \frac{\triangle F}{F} = \cos^2\theta \frac{\triangle H}{H} + \sin^2\theta \frac{\triangle V}{V}$$

Solar diurnal variations in the magnetic dip and in the total magnetic intensity, inclusive of disturbances. Annual mean values 1882–'83.

Ooglaamie civil time.	$\frac{\Delta H}{H}$	$\frac{\Delta V}{V}$	$\Delta\theta$	$\frac{\Delta F}{F}$	Ooglaamie civil time.	$\frac{\Delta H}{H}$	$\frac{\Delta V}{V}$	Δ	$\frac{\Delta F}{F}$
h. m.			′		*h. m.*			′	
0+53.6	−.00136	−.00009	+0.65	−.00012	Noon +53.6	+.00214	−.00018	−1.18	−.00013
1+53.6	249	+ 028	+1.41	+ 021	13 +53.6	276	014	−1.48	008
2+53.6	393	076	+2.39	+ 065	14 +53.6	346	014	−1.83	006
3+53.6	390	104	+2.51	+ 093	15 +53.6	488	027	−2.62	015
4+53.6	434	121	+2.82	+ 108	16 +53.6	593	035	−3.20	021
5+53.6	577	132	+3.61	+ 116	17 +53.6	589	050	−3.25	036
6+53.6	636	107	+3.78	+ 091	18 +53.6	601	061	−3.37	047
7+53.6	589	068	+3.34	+ 054	19 +53.6	486	090	−2.93	077
8+53.6	474	+ 039	+2.61	+ 027	20 +53.6	360	111	−2.40	101
9+53.6	274	− 002	+1.38	− 008	21 +53.6	250	097	−1.77	089
10+53.6	− 076	+ 001	+0.39	− 001	22 +53.6	+ 022	082	−0.58	080
11+53.6	+ 094	− 016	−0.56	− 014	23 +53.6	− 101	− 063	+0.19	− 064

In presenting the foregoing results of the three variation instruments I had two objects in view, viz: to be in a position to form a close estimate of the character and value of the whole series of observations preparatory to their full analysis and discussion, and, secondly, to give at once, but preliminarily, such leading results as could be deduced without waiting for the publication of the conclusions of the conference for the uniform treatment of the magnetic work at the International Polar stations. What has been presented will in general enable the reader to form a judgment of the magnetic character of the Ooglaamie station and of the value of the work done.

As has been already pointed out, there were no well adapted magnetic variation instruments available in the first year; the range of the collimator scale was very limited, and the declinometer had frequently to be turned in azimuth in order to secure readings on days of disturbance, besides the great changes in the torsion of the suspension renders it impossible to produce a uniform series with respect to a fixed direction. The record for the first year of the bifilar magnetometer has not yet been sufficiently examined to form an opinion as to its value, and at present I am still waiting for notes bearing on the adjustment and scale value of the instrument. There was then no vertical-force magnetometer, but hourly observations were made with a dipping needle deflected by a constant weight; corresponding values for the true dip or deflections by the same needle which had previously been used loaded were only made on two or three days each month, so that the value of this series as a differential measure of the total force may be regarded as small. It has, however, enabled me independently to verify the fact brought out by the balance magnetometer of the greater total intensity during the morning than in the afternoon hours. There is no record of the effect of temperature changes on the angle of deflection of the loaded needle.

In the year 1881–'82 there were but few stations with which to compare results, and to publish the above-mentioned records *in extenso* would seem to me an expenditure of time and labor hardly to be recommended, and probably not warranted by the meager results the series may be capable of yielding. I would propose to set down the mean of the 10 readings (5 with

scale extreme left and 5 with scale extreme right) for each instrument, viz: the declinometer and bifilar and the mean of the 10 readings of the dipping needle (5 for south and 5 for north end) for each observing hour, and during term days it would suffice to give only the mean of the two extreme scale readings. But on these points the result of the deliberations at Vienna may be awaited.

I conclude this report with a table of frequency of the aurora as seen and recorded in connection with the magnetic work at Ooglaamie:

Table of frequency of the aurora as observed at Ooglaamie, Alaska, between October, 1881, *and August*, 1883.

[The hours are local mean time hours at Ooglaamie, and the numbers indicate the number of days in each month when auroras were seen at each of the hours indicated.]

	0^{h}.	1^{h}.	2^{h}.	3^{h}.	4^{h}.	5^{h}.	6^{h}.	7^{h}.	8^{h}.	9^{h}.	10^{h}.	11^{h}.	N'n	13^{h}.	14^{h}.	15^{h}.	16^{h}.	17^{h}.	18^{h}.	19^{h}.	20^{h}.	21^{h}.	22^{h}.	23^{h}.	Total number of hours.
1881.																									
September.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
October.	2	2	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3	3	2	21
November.	13	15	15	13	14	12	5	3	2	0	0	0	0	0	0	1	2	2	4	6	9	12	14	12	154
December.	17	10	15	17	14	14	9	7	8	4	0	0	0	0	0	0	1	3	17	12	14	15	15	15	207
1882.																									
January.	11	16	9	9	7	3	1	2	2	1	0	0	0	0	0	0	0	1	8	7	9	11	10	16	123
February.	17	16	13	12	14	11	1	0	0	0	0	0	0	0	0	0	0	0	6	9	16	13	17	20	165
March.	17	17	14	10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	17	21	107
April.	7	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	21
May.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September.	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	7	23
October.	7	7	6	6	7	5	1	0	0	0	0	0	0	0	0	0	0	0	2	5	8	9	10	9	82
November.	14	14	14	12	12	12	11	9	0	0	0	0	0	0	0	0	2	4	5	7	12	12	16	19	175
December.	24	20	21	24	19	21	12	12	15	10	3	0	0	0	0	0	6	10	13	13	19	24	25	25	316
1883.																									
January.	20	22	23	20	19	19	17	18	12	2	0	0	0	0	0	0	0	10	9	11	17	20	22	21	282
February.	16	12	12	18	14	13	12	3	1	0	0	0	0	0	0	0	0	0	1	8	11	12	11	15	159
March.	21	18	19	18	15	5	1	0	0	0	0	0	0	0	0	0	0	0	0	7	14	18	21	20	177
April.	6	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	7	27
May.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum, Oct., '81, to Aug., '82, 10½ months.	84	79	71	63	53	40	16	12	12	5	0	0	0	0	0	1	3	6	36	35	51	60	77	94	798
Sum, Sept., '82, to Aug., '83, 12 months.	110	101	100	98	86	75	54	42	28	12	3	0	0	0	0	0	8	24	30	51	82	101	113	123	1241

Observations began October 17, 1881, and ended August 27, 1883.

The presence or absence of an aurora was noted a few minutes before each full hour. The total number of days when auroras were visible in the first ten and one-half months (1881–'82) was 145, hence, the average duration five and one-half hours nearly; the total number of days when auroras were seen in the year ending August, 1883, was 169, hence, the average duration seven and one-third hours nearly.

In the tabulation and preparation of the manuscript record for the printer I had the assistance of Sergeant Maxfield and Private G. W. Knopf, of the Signal Corps, who performed their task with much zeal and commendable industry; they have also prepared a complete duplicate of the hourly records submitted, but not printed, with this report.

Respectfully submitted by

CHAS. A. SCHOTT,
Assistant.

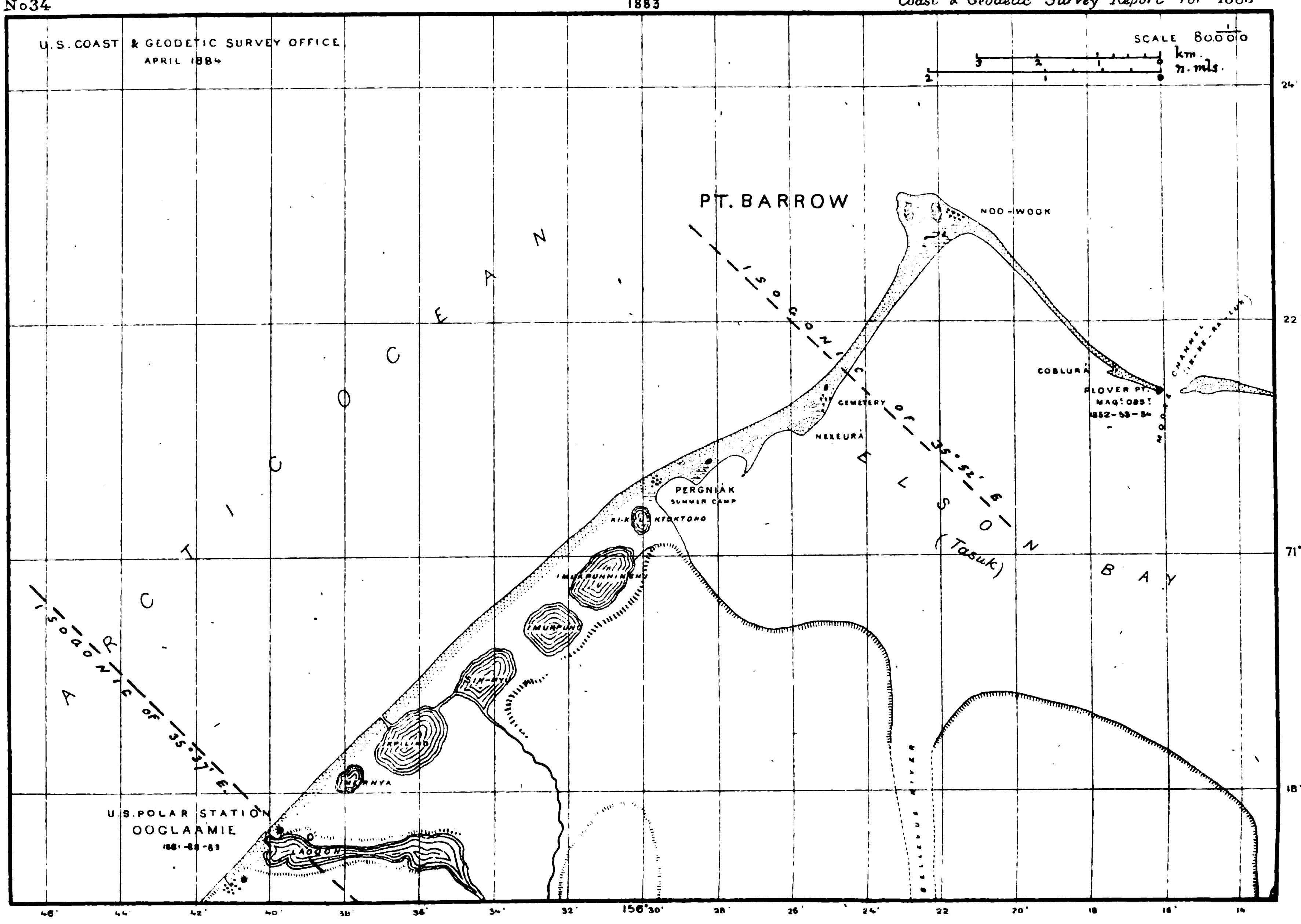
J. E. HILGARD, Esq.,
Superintendent Coast and Geodetic Survey.

No 34

DISTRIBUTION OF MAGNETIC DECLINATION AT POINT BARROW, ALASKA

1883

Coast & Geodetic Survey Report for 1883



APPENDIX No. 14.

REPORT ON THE PREPARATION OF STANDARD TOPOGRAPHICAL DRAWINGS.

By EDWIN HERGESHEIMER, Assistant Coast and Geodetic Survey.

SECOND SERIES

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, February 12, 1884.

DEAR SIR: I submit a second report upon the progress of the preparation of standard topographical drawing. Scale 1–10000.

The first report (Appendix 11, Coast and Geodetic Survey Report of 1879) dealt with the prevailing features (natural and artificial) of the Atlantic coast. The drawings herewith presented are special types, most of which are accompanied by views placed in their proper relation to the plan drawings. Little, therefore, need be said in addition to what is shown on their faces.

The drawings are:

1. A portion of the Potomac River and its banks, above Harper's Ferry, showing specially a railroad tunnel, water-worn rocks, middle drift sands, a river dam, and a mill-race to the former Government works at Harper's Ferry.
2. A gulch in disintegrated bituminous slate near Santa Cruz, Cal., with stratification of very gentle dip. This subject is drawn on 1–5000 scale, to give the details of the gulch more distinctly.
3. Brown's Mountain, Mount Desert Island, Maine. A rounded summit of a granite mountain, believed to be the result of the planing action of ice and its transported rocks.
4. Robinson's Mountain, Mount Desert Island. Abraded rock faces of a granite mountain.
5. Echo Mountain, Mount Desert Island. Cliff of a granite mountain, and fresh-water lakes.
6. Eagle Cliff, Mount Desert Island. Crest, face, and talus of a granite cliff.
7. Cape Disappointment, Washington Territory. A basaltic promontory.
8. The Dalles of the Columbia River. A remarkable erosion of eruptive rocks, where a great river has cut through successive basaltic overflows, leaving a narrow gorge trough, and a succession of bold basaltic escarpments. Also, a representation of a rapid river torrent.

Other special types have been drawn:—the moraines of Fallen Leaf Lake, California, a portion of Table Mountain, California, illustrating the "Deep Placers," the vicinity of Plymouth, Mass., illustrating the eroded "Great Drift" of New England, and a sample of marine erosion of a headland on the Pacific coast. These will form part of a third report when engraved.

Respectfully yours,

E. HERGESHEIMER,
Assistant Coast and Geodetic Survey.

Prof. J. E. HILGARD,
Superintendent Coast and Geodetic Survey.

NOTE.—It has been deemed advisable to republish with this the first series of standard topographical drawings, which appeared as Appendix No. 11, Report for 1879.

APPENDIX NO. 11.

REPORT ON THE PREPARATION OF STANDARD TOPOGRAPHICAL DRAWINGS, BY EDWIN HERGESHEIMER, ASSISTANT COAST AND GEODETIC SURVEY.

FIRST SERIES.

[From the report for 1879.]

OFFICE OF THE UNITED STATES COAST AND GEODETIC SURVEY,
Washington, July 1, 1879.

SIR: In the preparation of topographical drawings to be used as guides for inking the original plane-table sheets of the Coast and Geodetic Survey, selection was first made of such features, natural and artificial, as are most prevalent on our coasts.

The first subject was the representation of closely-built cities, comprising large public buildings, warehouses, &c., and suburban villas and grounds of the first class. Newport, R. I., was selected for this purpose, where it was found desirable to discontinue the inking of large buildings in full black, and to confine the black to the exterior, representing the outer walls, and to tint the interior by fine lines closely ruled. Carriage-ways and walks of villa or public grounds are here represented in full light line, instead of the broken line formerly used. Fresh marsh is also represented in a style different from that heretofore in use. Its representation had previously been by irregularly distributed tufts of grass, underlined by free hand with water lines, which, drawn with taste, is perhaps the most artistic representation of the feature, but which is seldom represented the same by any two persons. It was therefore thought best to introduce a style that could be definitely described and required. For this purpose lines of the same strength and the same distance apart as those of the salt marsh are ruled and irregularly broken, then interlined and tufted by free hand with light short lines grouped irregularly, as shown in the first of the series of sketches accompanying this paper.

For the representation of a town sparsely settled, Brunswick, Ga., is given, on which salt marsh, pine woods, ditches, fences, undefined roads, and wagon tracks are shown.

For the representation of railroads, canals, iron bridges, bold faces of rock, mid-river drift, water-worn rocks, and distribution of mixed woods over close hill curves, the vicinity of Harper's Ferry is given. Here is illustrated the strengthening of the 100-feet hill curves for the more ready reading of the heights of hills.

For the representation of heavy oak timber, reclaimed marsh and orchards, a part of the New Jersey shore of the Delaware River is given.

For the representation of rice, and the dikes and ditches incident to its cultivation, a selection from Santee River is given.

For the representation of eroded drift banks with bowlders set free, and scrub deciduous woods, the western part of Martha's Vineyard, including Gay Head, is given.

For the representation of the rocky shores and intermediate sand and shingle beaches, beaches above high water, and eroded earth banks, characteristic of the coast of New England, roads, fences, residences, outhouses, shade-trees on the lines of roads, and the shading of low hills by normals, the extreme end of Nahant is given.

For the representation of a sandy beach, with low dunes, fresh-water ponds, meadow grass, sage-brush, fresh marsh, and eroded gullies (arroyas), a selection from the vicinity of San Luis Obispo was made.

Samples not yet engraved have also been drawn for various characters of eroded and fractured granite rocks, as shown at Mount Desert Island; hard, eruptive rocks, as shown at Cape Disappointment, Oregon, and eroded sedimentary forms at Arlington, Va.

Respectfully, &c.,

E. HERGESHEIMER,
Assistant.

CARLILE P. PATTERSON,
Superintendent.

No. 35.

Report of 1883

TOPOGRAPHICAL DRAWING

Scale $\frac{1}{10\,000}$

By E. Hergesheimer Assistant

R.R. Tunnel, Water-worn Rocks, Drift Middle Sands, River Dam, Mill Race, (Potomac River)

TOPOGRAPHICAL DRAWING
Scale $\frac{1}{5000}$
By E. Hergesheimer Assistant

Erosion of Soft Stratified Rock and Gulch, (Santa Cruz, California)

U. S. COAST AND GEODETIC SURVEY
J. E. Hilgard. Superintendent

No. 37.

Report of 1883

TOPOGRAPHICAL DRAWING
Scale $\frac{1}{10000}$
By E. Hergesheimer Assistant

Rounded Summit of a Granite Mountain. (Brown's Mt., Mt. Desert Id.)

E. H.

G. Mc. C.

Brown's Mountain (Looking South.)

Drawn by E. Hergesheimer

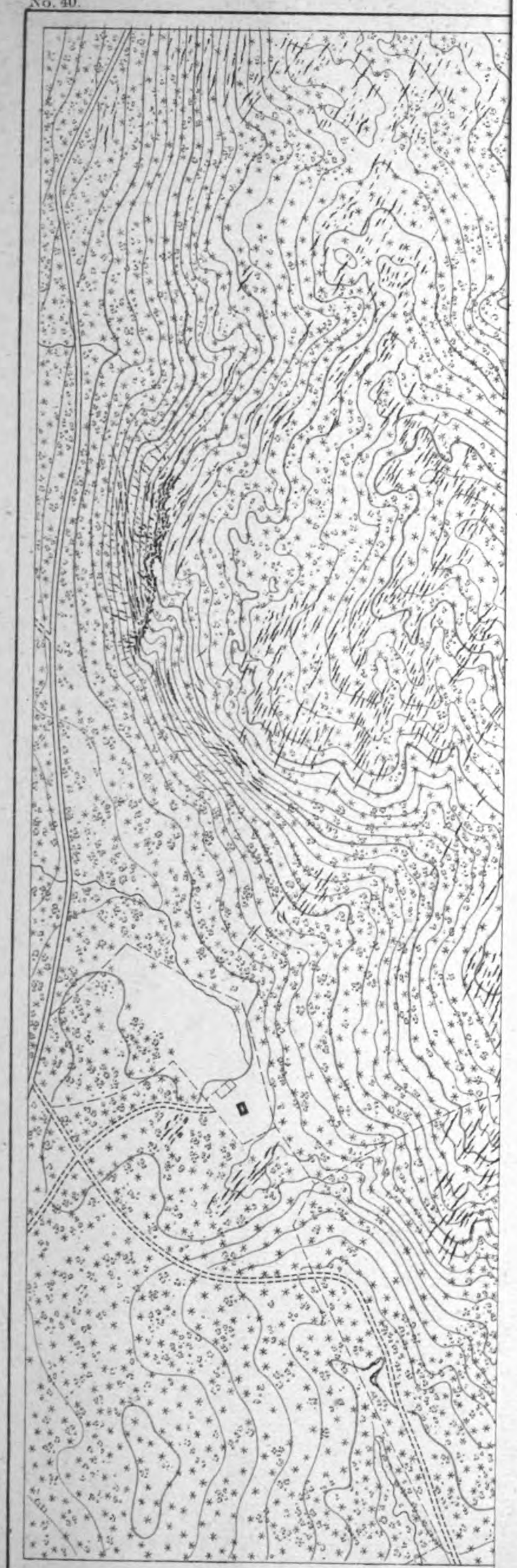
Engraved by G. Mc. Coy

Brown's Mountain (Looking North West.)

U.S.COAST

J.E.H

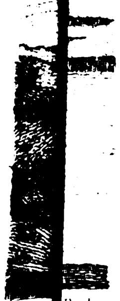
No. 40.



TOPOG

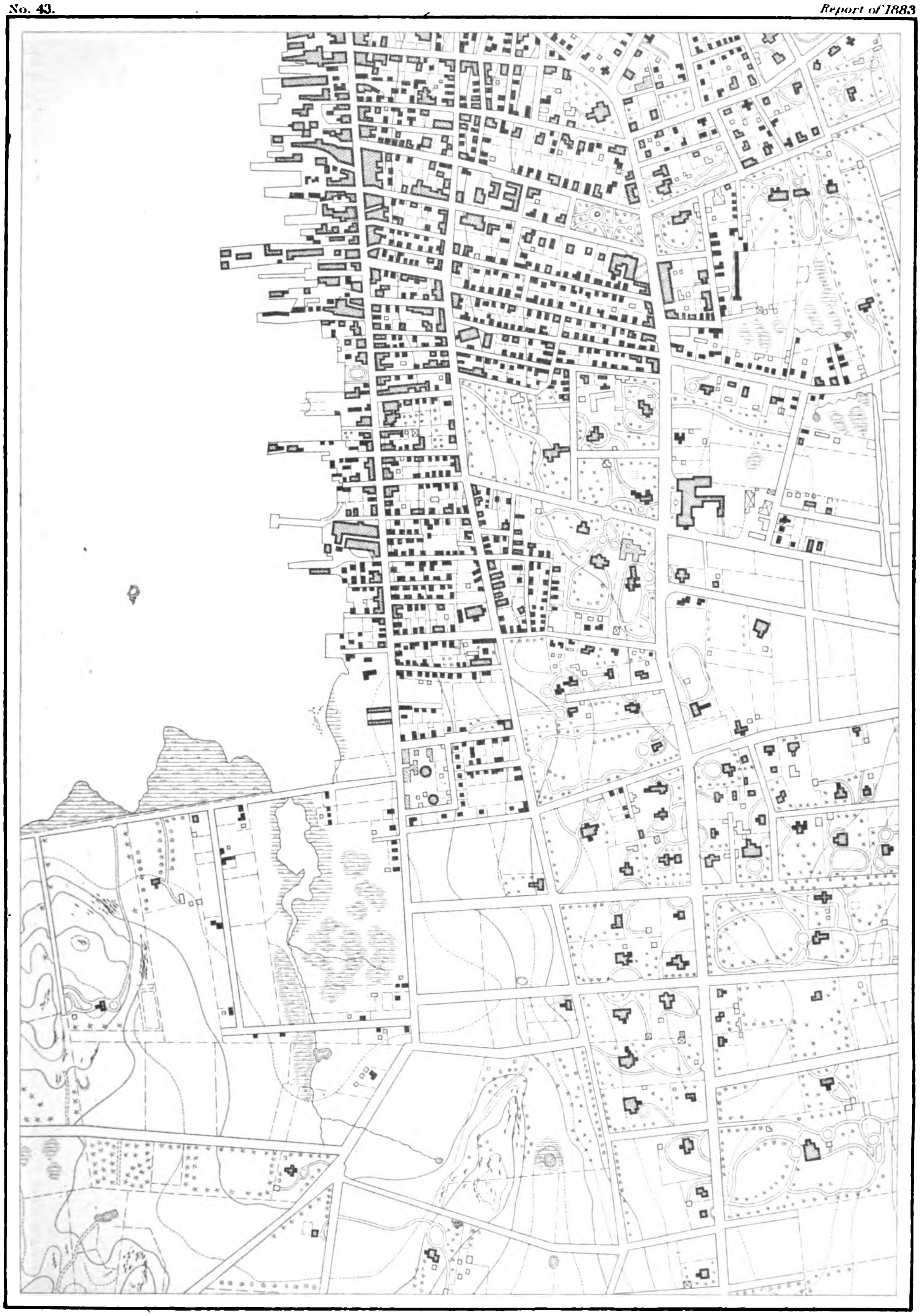
By E.H

Crest, Face and Talus of a



U. S. COAST AND GEODETIC SURVEY
C. P. Patterson Superintendent

No. 43. Report of 1883



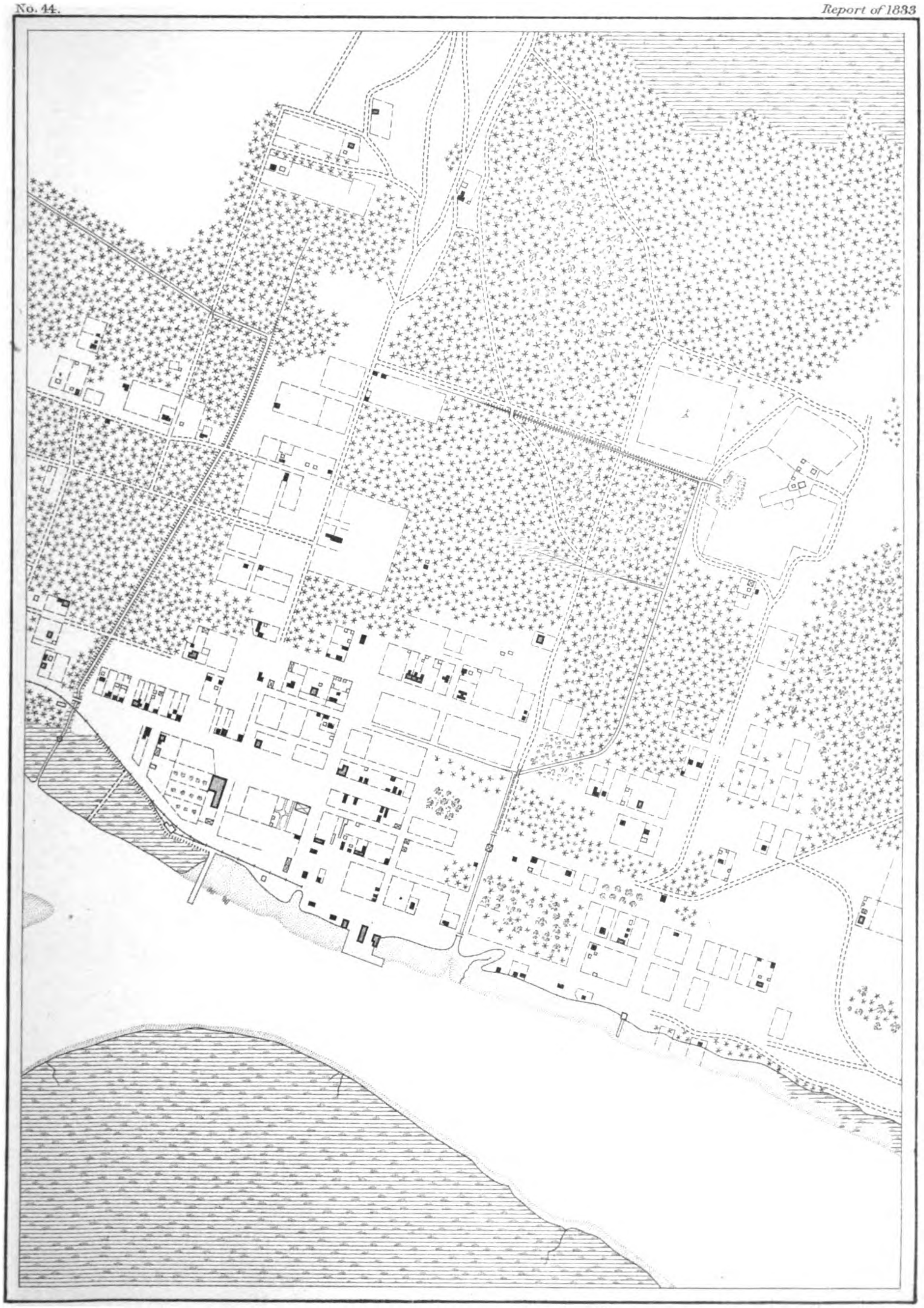
TOPOGRAPHICAL DRAWING
Scale $\frac{1}{10\,000}$
By E. Hergesheimer Assistant

Blocking of Cities, Large Buildings, Suburban Villas and Grounds, Fresh Marsh (Newport R. I.)

U. S. COAST AND GEODETIC SURVEY

C. P. Patterson Superintendent

No. 44. Report of 1883



TOPOGRAPHICAL DRAWING

Scale $\frac{1}{10\,000}$

By E. Hergesheimer Assistant

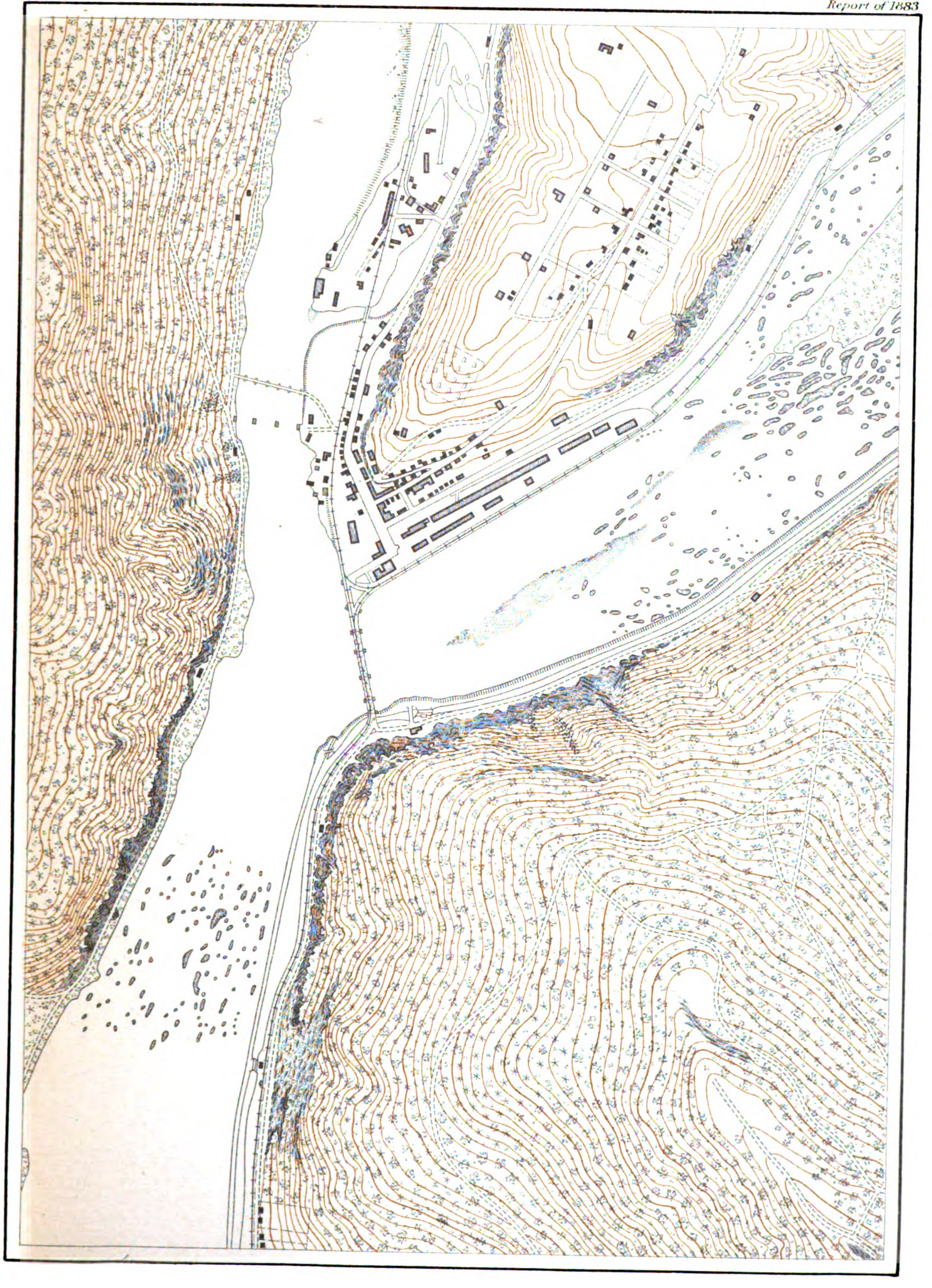
Sparsely settled Town, Salt Marsh, Pine Woods, Ditches, Fences, and Undefined Roads (Brunswick, Ga.)

U. S. COAST AND GEODETIC SURVEY

C. P. Patterson Superintendent

No. 45.

Report of 1883

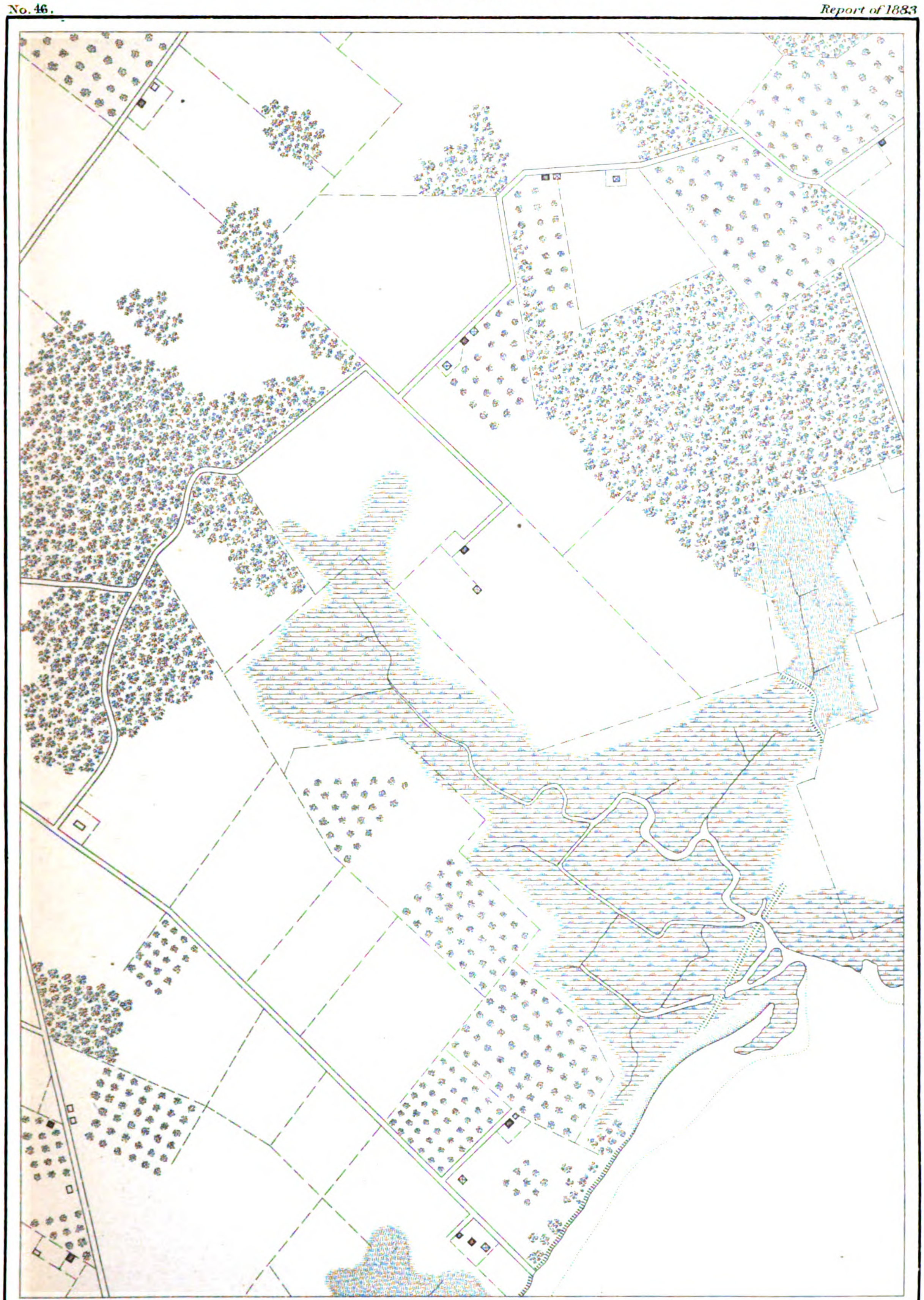


TOPOGRAPHICAL DRAWING

Scale $\frac{1}{10\,000}$

By E. Hergesheimer Assistant

Railroads, Canals, Iron Bridges, Rocky-cliffs, Mid-river drift, Water worn Rocks, Mixed Woods over hill curves (Harper's Ferry.)

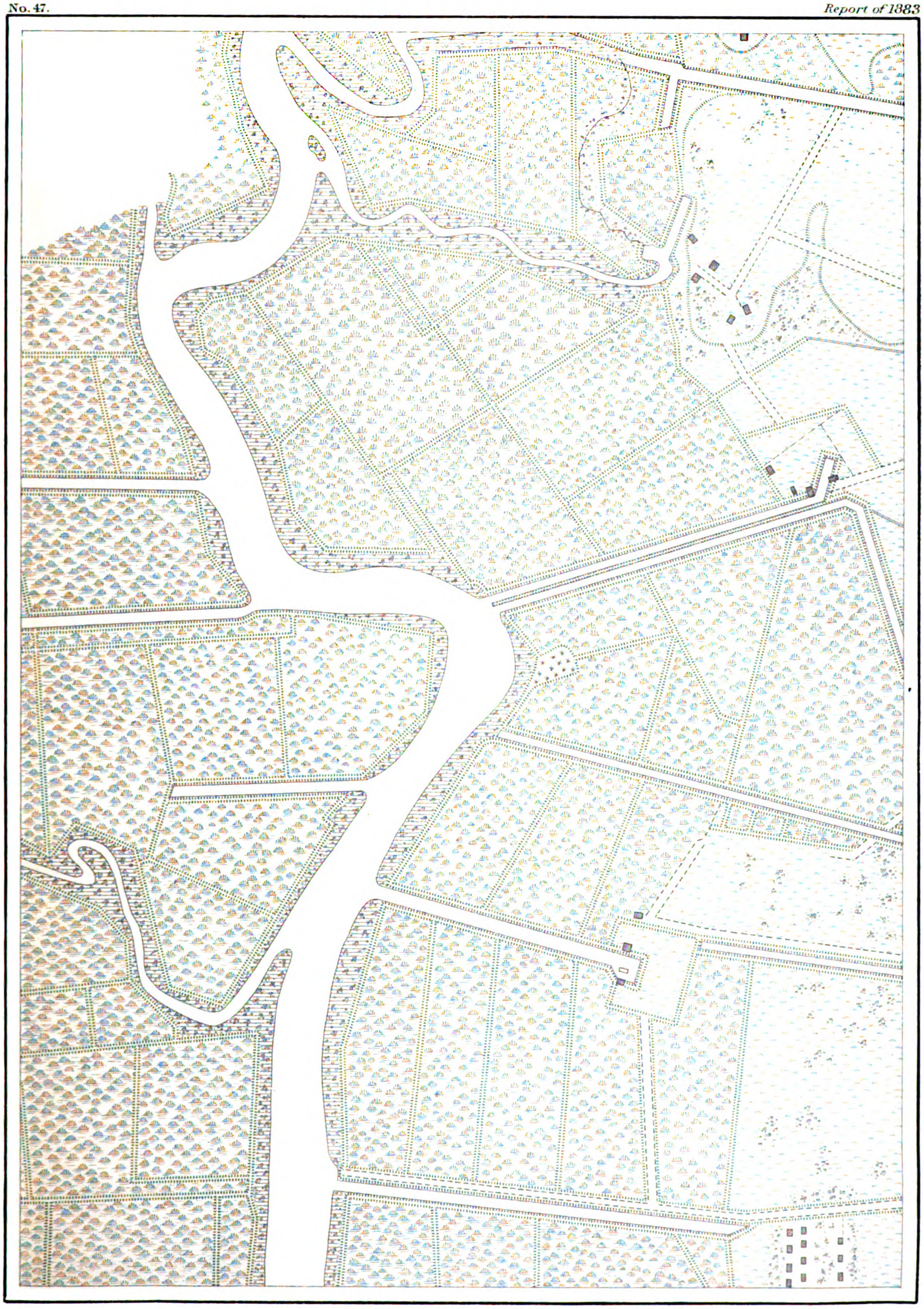


TOPOGRAPHICAL DRAWING

Scale $\frac{1}{10\,000}$

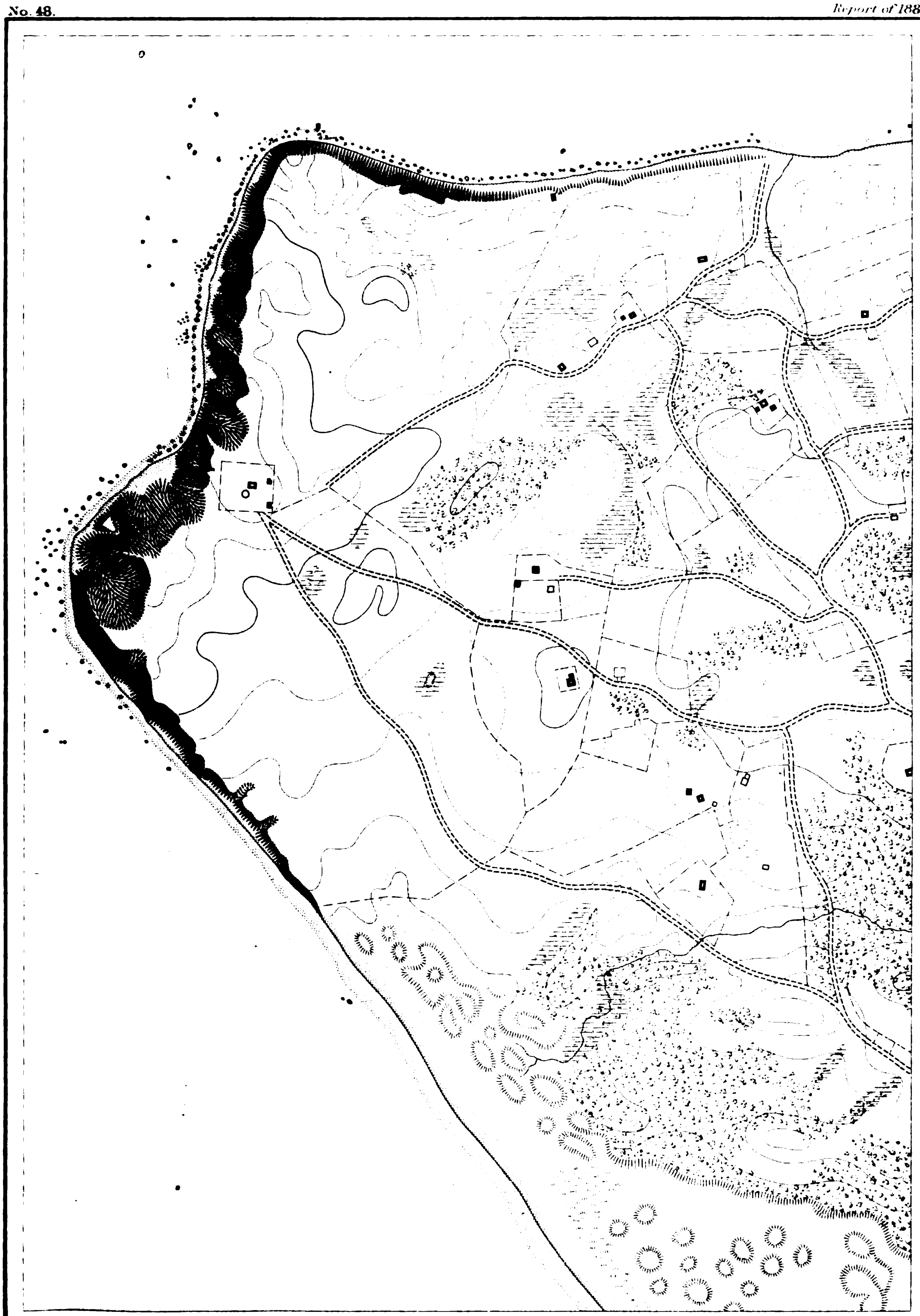
By E. Hergesheimer Assistant.

Heavy Oak Woods, Reclaimed Marsh and Orchards (Delaware River)



TOPOGRAPHICAL DRAWING
Scale $\frac{1}{10\,000}$
By E. Hergesheimer Assistant

Rice, Dykes and Ditches (Santee River)



TOPOGRAPHICAL DRAWING
Scale $\frac{1}{10\,000}$
By E. Hergesheimer Assistant

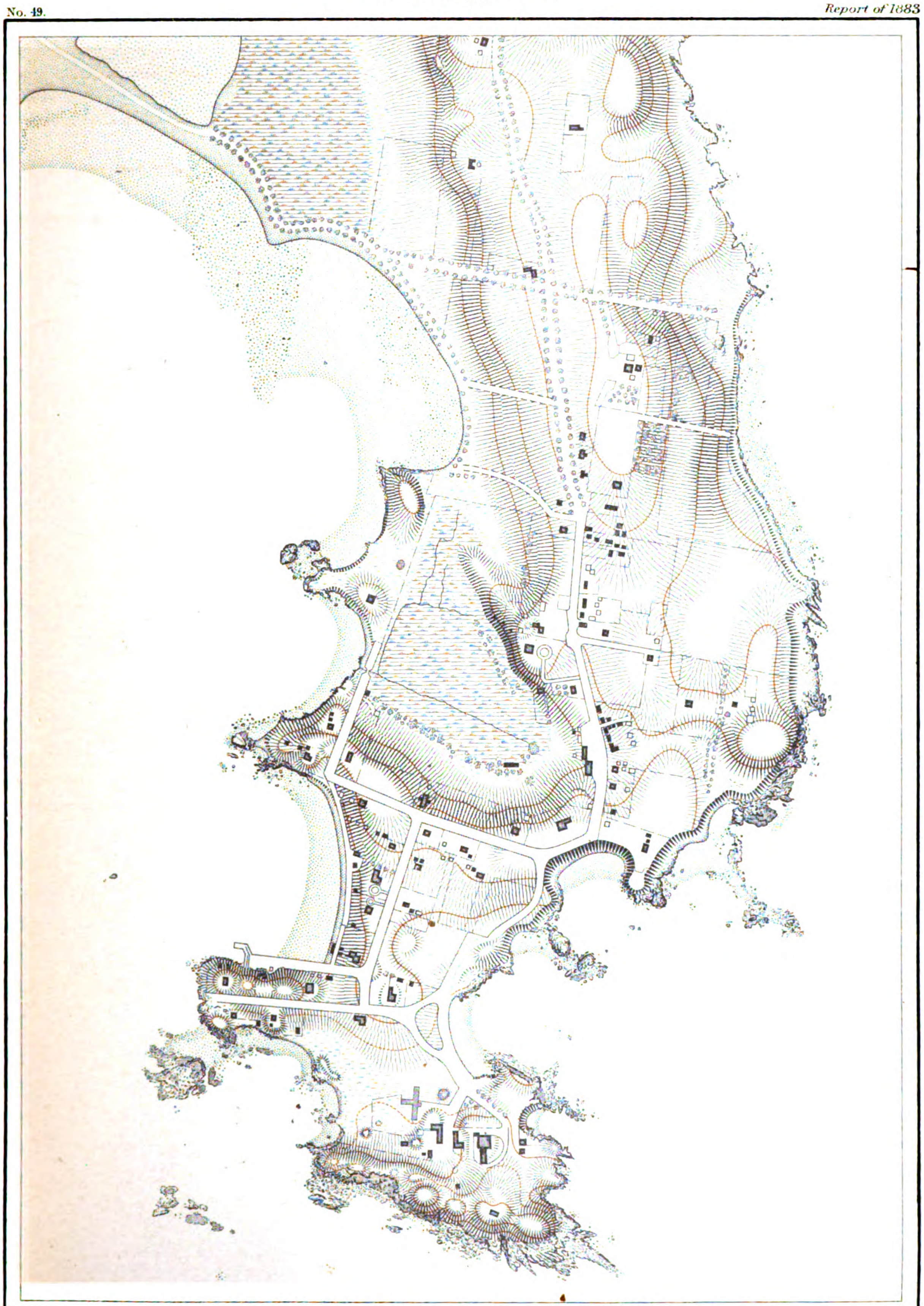
Eroded drift banks, with boulders set free; and scrub deciduous woods (Gay Head)

U. S. COAST AND GEODETIC SURVEY

C. P. Patterson Superintendent

No. 49.

Report of 1883



TOPOGRAPHICAL DRAWING

Scale $\frac{1}{10\,000}$

By E. Hergesheimer Assistant

Sand and Shingle Beaches, Eroded Earth Banks, Roads, Fences, Dwelling and Out-Houses, Shaded Road-sides, Hill-shading (Nahant)

TOPOGRAPHICAL DRAWING
Scale $\frac{1}{10000}$
By E. Hergesheimer Assistant

Sand Beach with Low Dunes, Fresh Water Pond, Meadow Grass, Sage Brush and Arroyos (S. Coast of California)

APPENDIX No. 15.

THE TRANSIT OF MERCURY OF NOVEMBER 7, 1881, AS OBSERVED AT YOLO BASE, CALIFORNIA.

By GEORGE DAVIDSON and J. J. GILBERT, Assistants.

At a point near the United States Coast and Geodetic Survey station "Southeast Yolo base," I observed the II contact of Mercury at the transit of that planet over the sun's disk on the 7th of November, 1881.

I used a 3-inch Fraunhöfer telescope known as the "Hassler Equatorial" belonging to the Survey, and mean time pocket chronometer Widenham 900. The eye-piece was direct, and had a power of 105 diameters.

The geographical position of the point of observation deduced from measures to the Yolo base station is

Latitude: 38° 31′ 33″.8 north.
Longitude: 121° 47′ 56″.9 west of Greenwich.

The chronometer was slow of local mean time at ingress $9^m\ 52^s.7$.

Having no position circle I was not looking at the right place on the sun's limb at the time of I contact, and when I first saw the planet it had entered quite perceptibly on the sun. The atmosphere was moderately steady, and there were undulations of the limbs of Mercury and the sun, which gave a certain overlapping of borders such as might be considered a "ligament." Nevertheless this disturbance was not great enough to prevent a good observation being made, and I noted

	h. m. s.	
II contact, at	2 01 38.8	by chronometer.
Chronometer correction =	+9 52.7	
II contact, at	2 11 31.5	local mean time,
or	5 10 31.2	Washington mean time.

When the planet was one diameter on the sun's disk by estimation I noted the time, by the chronometer $2^h\ 03^m\ 20^s$.

The planet presented an intensely black disk, which in its regularity and color was in marked contrast with the solar spots near which it passed, and which would themselves be called quite regular in form and dark in color. There was no white spot on the planet, and no annulus of bright light around its disk, nor any indication of distortion.

The observations for the error of the chronometer were made with a Gambey sextant and artificial horizon by Mr. C. B. Hill, attached to the main triangulation party.

J. J. Gilbert assistant United States Coast and Geodetic Survey, was attached to my party, and at the time of the transit was at the Middle Base Camp, where he observed the transit of Mercury with a 3 inch Fraunhöfer reconnoitering telescope No. 12, United States Coast and Geodetic Survey, lacking, however, slow motion in the horizontal and vertical. The instrument is otherwise similar to the Hassler Equatorial, and was used with the same power.

The geographical position of the telescope, by connection with the Yolo base was

Latitude: 38° 35′ 18″.2 north.
Longitude: 121° 49′ 17″.0 west of Greenwich.

The observer's watch was 2^{m} $49^{s}.6$ slow of local mean time. Having no position circle the observer did not see the planet until it was on the sun's limb, and made the following observations:

		h. m. s.	
Observed time,	I =	2 07 40.5	planet ½ diameter on sun.
	II =	2 08 49.5	
Correction to watch,	+	02 49.6	
Then	I =	2 10 30.1	local mean time (planet ½ diameter on sun).
	II =	2 11 39.1	local mean time.
Or,		5 10 44.1	Washington mean time.

The observations for the error of the watch were made by Messrs. Gilbert and Hill, using a Gambey sextant and artificial horizon.

Remarks.—The sky was clear and weather quite warm, but a very strong north wind was blowing over the plains through the Sacramento Valley, so that the observers had to seek sheltered places for the telescopes. No extra preparation was made for the observations, because the regular work of the measurement of the Yolo base line of 11 miles' length was in progress. The elevation of the stations is about 75 or 80 feet above the sea level; the plains extend for 60 miles to the east, indefinitely to the north and south, and 12 miles to the west, to the Berryessa range of coast mountains, reaching 3,300 feet elevation at Berryessa Peak.

At the first station the sun's disk at the time of ingress was not sharp and well defined, but somewhat blurred, and the unsteadiness gave to the phenomenon of first internal contact the frequently reported appearance of distortion of the planet's limb next to the sun's limb, known by a variety of names such as the "black ligament," "black drop," &c., but never coming to the black drop depicted in many previous reports. But at the second station this appearance did not present itself, whilst the closeness of the two observed times indicated little disturbance in reality. The phenomenon of this atmospheric disturbance is familiar to Mr. Gilbert and myself from many years' observing during the day-time on signals of the Geodetic Survey.

The intense blackness of the planet's disk and its regular form satisfied us both that a body of one-fourth of the diameter of Mercury, such as the problematical planet Vulcan, could be readily distinguished with the same telescopic means that we used, whilst its progress across the sun's disk, and its contrast with contiguous solar spots would effectually prevent any mistake by an experienced observer.

The observations for time and their reduction were made by Mr. Hill, to whom I am also indebted for the reduction of the geographical positions from the base line.

Respectfully submitted.

GEORGE DAVIDSON,
Assistant United States Coast and Geodetic Survey.

J. E. HILGARD, Esq., *Superintendent.*

APPENDIX No. 16.

OBSERVATIONS OF THE TRANSIT OF VENUS OF DECEMBER 6, 1882, AT WASHINGTON, D. C., AND AT TEPUSQUET STATION, CALIFORNIA, AND AT LEHMAN'S RANCH, NEVADA.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., December 6, 1882.

SIR: The following account of observations of the Transit of Venus made to-day at Fauth's observatory, Washington, D. C., is herewith respectfully submitted.

The place of observation is the same as that occupied by me when observing the Transit of Mercury May 6, 1878, namely, opposite the southwest corner of the lower Capitol park,* by measure 8″.7 south and 9″.4 west of the center of the dome of the Capitol,† or in latitude 38° 53′ 14″.5 and in longitude 77° 00′ 42″.9, or $5^h\ 08^m\ 02^s.9$, which is $9^s.1$ east of the dome of the United States Naval Observatory.

Through the kindness of Mr. Fauth I had the use of his new equatorial (for which he was awarded a gold medal at the late Cincinnati Exposition); it is driven by clockwork, has an aperture of 15.25 centimeters (6 inches), a focal length of 2.5 meters (8.2 feet), and was used with a magnifying power of 102 for the morning observation, and with a power of 127 for the afternoon observations. Full aperture was used in connection with a solar eye-piece, the prism of which deflected so much of the sun's heat and light that a light shade-glass sufficed for the protection of the eye. I was assisted by Dr. J. G. Porter, computer in the Survey Office, who took charge of the chronometer (mean time chronometer, Bond & Sons, No. 177), noting down the time and remarks made by the observer.

In the morning the southeastern sky was covered with dense cirro stratus clouds; it was therefore fortunate that a fine focal adjustment of the telescope had been obtained the night before on Saturn, which focus had been preserved.

First external contact.—Very light yellow shade-glass over the eye-piece. No distinct vision of the sun could be had until about two or three minutes after the predicted time of the contact. The eye was kept steadily at the spot where the planet was to appear, but the limb of the sun could only be seen faintly by glimpses and by slightly vibrating the telescope.

	h. m. s.	
Record: At	8 54 15	(by chronometer) limb barely visible.
	8 56 47	notch seen.

The sun was then rising above the denser cloud bank and the seeing continually improved. This observation is of no value. Changed color of shade-glass to a light neutral tint.

First internal contact.—It was seen through thin clouds, the image of the outlines of sun and planet in a state of slow undulation and devoid of sharpness, yet the observation appeared to the observer quite satisfactory considering the entire absence of any distorsion of figure or other disturbing phenomenon; in fact the appearance was that of a geometrical contact.

	h. m. s.	
Record: At	9 13 0	(by chronometer); sun's image boiling, no sharp outline to Venus.
	9 13 58	cusps nearly together.
	9 14 50	first momentary closing of line of light.
	9 15 04.5	apparent permanent connection.

* Southeast corner First street west and B street south; elevation above sea 20 feet, about.

† Latitude 38° 53′ 23″.2, longitude 77° 00′ 33″.5, the most recent geodetic determination.

Just before the internal contact the cusps appeared blunted and were not finely drawn out. At 9^h 14^m 50^s the wavy motion of the limb first united the cusps by a rather thick streak of light closing momentarily around Venus, but the connection was not permanent until at 9^h 15^m $04^s.5$

In my judgment this first moment will represent the true time of first interior contact, thus 9^h 14^m 50^s plus chronometer correction (for which see further on), or + 1^m $30^s.5$, gives for inner contact 9^h 16^m 21^s United States Naval Observatory mean time, with an estimated uncertainty of ± 5^s.

Second internal contact.—Was observed through a (darker) neutral tint shade-glass, very agreeable to the eye; only light clouds passing over the sun's disk, with occasional perfect clearness. The boiling motion of the image was, however, much more rapid than in the morning, yet the extent of the wave motion or tremor was very much less. Venus appeared with a jagged outline in a state of tremor, and of an even black color, as in the morning, no indication of any atmosphere or distorsion of figure being noticed, the phenomenon passing off very much as in the morning without any disturbing features, except the boiling.

	h.	*m.*	*s.*	
Record: At	2	37	47.5	(by chronometer) very thin line of light.
	2	38	08.5	first break of line of light.
	2	38	23	permanent break.

When the first momentary break occurred in the line of light it was still of sensible thickness through the effect of wave motion, and when the cusps had actually formed at 2^h 38^m 23^s they were blunt, and not sharply pointed. Just before this time the connecting streak appeared like a collection of patches of light. I should judge the true internal contact took place about one or two seconds after the middle time noted, or at 2^h 38^m $08^s.5$ + $1^s.5$+ chronometer correction (+ 1^m $30^s.5$), hence, second inner contact at 2^h 39^m 41^s United States Naval Observatory mean time, with an estimated uncertainty of ± 5^s. The observation is considered quite satisfactory by the observer.

The last contact.—The sky being clear or nearly clear, the only difficulty in observing this external contact was occasioned by the strong boiling motion of the sun's limb. The observer, keeping his eye steadily at the slowly diminishing notch, noted two phenomena, viz:

	h.	*m.*	*s.*	
Record: At	2	56	55.5	(by chronometer) notch disappearing momentarily through undulations.
	2	57	47	last appearance of something resembling a notch.

The first time is that when the notch began to be obliterated by passing waves and the last contact had apparently not yet occurred; the second time is that when the passing waves last failed to bring out a notch, and the last contact apparently had then taken place. I should think true external contact took place about that moment, or at 2^h 57^m 47^s + 1^m $30^s.5$, or last contact at 2^h 59^m 18^s United States Naval Observatory mean time. In consequence of the serrated outline of the sun the uncertainty of this phase I estimate at ± 20^s.

While the observations of the inner contacts may be taken as fairly satisfactory, the presence of clouds at ingress prevented, and the atmospheric tremor at egress, detracted so much from the accuracy of the observation that the time of the external contact is considered to be of little value.

To obtain the chronometer correction the dropping of the noon time-ball at the Naval Observatory was observed as follows:

	h.	*m.*	*s.*	
December 4. Ball coming down at.......... ...	11	58	32.3	(Bond & Son's 177.)
5. Ball coming down at.......		58	30.5	
6. Ball coming down at.............		58	29.5*	

The original pencil notes are on file at the Survey Office, and the correct transcript of the record is attested over our signature.

CHAS. A. SCHOTT,
Assistant Coast and Geodetic Survey.
J. G. PORTER,
Computer Coast and Geodetic Survey Office.

To J. E. HILGARD, *Superintendent.*

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* Note added after the report was written: Ball apparently not hoisted December 7 on account of high wind.

P. S.—On December 7, in the morning, Mr. B. A. Colonna, Assistant, handed me an account of his observations of the Transit, and I herewith append the same. Assistant Colonna was a member of the party stationed at Mr. Fauth's establishment, and used one of his instruments.

C. S.

WASHINGTON, D. C., *December* 7, 1882.

SIR: By invitation of Assistant C. A. Schott, under whose direction suitable telescopes had been provided and placed in the yard of Fauth & Co.'s shop, at the southeast corner of First and B streets southwest, I repaired to that place in due season on the 6th day of December, 1882.

From a number of telescopes that I found there I selected one of small size, not as being so powerful as the larger ones that were available, but principally because, while giving a moderately fair chance for good results, it had the advantage of having a finder attached to it. This finder having a small magnifying power (about 10 diameters) was of service, in that while the thin clouds continued to pass the sun's disk and obscure it entirely about the time of first contact, I could rapidly scan any part that chanced to be showing for a moment. By means of this finder I think I obtained amongst the earliest views of the beginning of the Transit.

For a few minutes after sunrise on this occasion the sun's disk was beautifully clear and distinct, not a cloud was near it, and to the casual observer nothing would have been apparently more certain than complete success, but soon a long, low, narrow, black cloud formed, about 15° above the horizon and to the southward of the sun. This cloud gradually moved to the northward, spreading out to greater width, and at last totally obscuring the sun. This state of affairs continued until about fifteen minutes before first contact, when not only from the sun's increased height, but also because the cloud began to break up and disperse, we began to get occasional glimpses of parts of the face and circumference of the sun, matters were gradually improving in this way at the time of first contact, at which time I could make out the circumference of the sun through thin clouds, using the finder without any colored glasses; then the clouds got a little thinner, and these were the circumstances under which I first saw Venus after she had slightly advanced on the sun's disk, using the finder and no colored glasses, as heretofore stated.

TRANSIT OF VENUS.

Station: Yard of Fauth & Co.'s shop, Washington, D. C.

Observer and recorder: B. A. Colonna, Assistant Coast and Geodetic Survey.

INSTRUMENTS.

For time.—Mean time chronometer, Bond & Sons slow, 1^m 30^s (Schott); Colonna's mean time watch (Crescent St. movement).

For observation.—Reconnoitering telescope by "Ploessel in Wien," mounted on tripod stand, movement by hand and in any direction. Focal length 96.5 centimeters, or 38 inches. Clear aperture 90 millimeters. Magnifying power 140 diameters. Finder attached to reconnoitering telescope about 10 inches long, with magnifying power about 10 diameters.

Comparison of time pieces, a. m., December 6, 1882.

Instruments.	Before contacts.	After contacts.
	h. m. s.	*h. m. s.*
Mean time chronometer, Bond & Son, No. 177	7 57 00	9 19 00
Colonna's mean time watch	7 58 35	9 20 35
Mean time chronometer, Bond & Son No. 177	7 58 00	9 20 00
Colonna's mean time watch	7 59 35.5	9 21 35.2
Mean time chronometer, Bond & Son No. 177	7 59 00	9 21 00
Colonna's mean time watch	7 60 35.5	9 22 35.5

	h. m. s.
Mean time chronometer at comparison (No. 177)	7 57 00
Chronometer slow	1 30
Corrected mean time of comparison	7 58 30
Colonna's mean time watch at comparison	7 58 35
Colonna's mean time watch fast	05

1. First external contact.—Was over before clouds broke away. I noted it down when first seen, $8^h\ 58^m\ 00^s$.

I judge that the planet was five minutes on before I saw her, on account of clouds.

2. First internal contact:

	h. m. s.	
A. M.	9 15 25	might be.
	9 16 20	apparently better.
	9 17 00	might be.
	9 16 15	mean.
Colonna's watch fast	—05	
Corrected time of observation	9 16 10	

At $9^h\ 33^m\ 30^s$ she was about one diameter on.

NOTE.—I am very sure that for the five minutes preceding first internal contact I saw the limb of the planet outside of the sun's disk. The atmosphere was tremulous. There were passing clouds which had totally obscured the sun for an hour before the Transit began. At the time of the first external contact the clouds were just beginning to clear away.

Comparison of time pieces, p. m., December 6, 1882.

Instruments.	Before contacts.	After contacts.
	h. m. s.	h. m. s.
Mean time chronometer, Bond & Son, No. 177	2 13 00	3 02 15
Colonna's mean time watch	2 14 32.5	3 03 48
Mean time chronometer, Bond & Son, No. 177	2 14 00	3 03 00
Colonna's mean time watch	2 15 32.5	3 04 32.5
Mean time chronometer, Bond & Son, No. 177	2 15 00	3 03 30
Colonna's mean time watch	2 16 33	3 05 02.5

	h. m. s.
Mean time chronometer, No. 177, at comparison	2 13 00
Correction to mean time chronometer slow	+ 1 30
Corrected mean time of comparison	2 14 30
Colonna's mean time watch at comparison	2 14 32.5
Colonna's mean time watch fast	02.5

3. Second interior contact:

	h. m. s.	
	2 39 30	perhaps.
	2 40 03	better, I think.
	2 40 20	perhaps.
By Colonna's watch	2 39 58	mean.
Colonna's watch fast	03	
Corrected mean time of contact	2 39 55	

NOTE.—After the second interior contact I expected again to be able to see the disk of Venus for five minutes after it had passed beyond the sun's disk, but I could not. The instrument is in the same focus as when used this a. m. The sun has been partially obscured for the preceding thirty minutes, but is now entirely clear. The atmosphere is quite tremulous, more so, I think, than it was this morning. I failed to see any of the rolling appearance of the light when the thread became very fine that I have seen elsewhere on similar occasions.

4. Second exterior contact:

	h. m. s.	
	2 59 30	perhaps.
	59 60	better.
	59 80	perhaps.
Time of observation by Colonna's watch	2 59 56.7	mean.
Fast.	2.5	
Corrected mean time of observation	2 59 54.2	

After this contact time was compared, as shown before, and my observations of the Transit of Venus were concluded.

NOTE.—As to the observer, I would state that he purposely abstained from all knowledge concerning the computed times of contact, of transit, and all other information at all calculated to influence his observations.

I have the honor to be your obedient servant,

B. A. COLONNA,
Assistant.

Prof. J. E. HILGARD, *Superintendent.*

STATION LOSPE,
Santa Barbara County, California, January 27, 1833.

SIR: Mr. P. A. Welker reports to me his observations of IIId and IVth contacts of Transit of Venus, December 6, 1882, as follows:

Station: Tepusquet, Cal., latitude 34° 54′ 30″.5 north; longitude 120° 11′ 14″.9 west of Greenwich.

Observer, P. A. Welker; recorder, H. Stoddard.

Weather: Fair, cloudless. Atmosphere: Remarkably clear. Wind: calm.

Instrument: 12 inch theodolite, 131 (Fauth & Co.). Total length of telescope, 26.0 inches; aperture of telescope, 2.5 inches; magnifying power of eye-piece, not determined. Chronometer, sidereal chronometer 207 (John Hutton). Two colored glasses taken from a sextant and placed one over the other, were fastened to eye end of telescope.

Outlines of sun and planet were very sharp and distinct.

Just before Contact III a bright ring of light was seen between limbs of sun and planet Time was marked when this ring disappeared.

At time of IVth contact limbs of sun and Venus well defined—no unusual disturbance.

After IVth contact Venus could not be seen.

	h. m. s.
Chronometer time of IIId contact	16 53 19.0
Chronometer error at time of IIId contact	− 12.7
Sidereal time of IIId contact	16 53 06.3
Chronometer time of IVth contact	17 13 15.0
Chronometer error at time of IVth contact	− 12.8
Sidereal time of IVth contact	17 13 02.2

Hourly rate of chronometer from observations before and after Transit of Venus = $0^s.248$ gaining.

Very respectfully,

JAS. S. LAWSON,
Assistant.

J. E. HILGARD, Esq., *Superintendent.*

LEHMAN'S RANCH, NEVADA, *December* 7, 1882.

SIR: I beg leave to present the following report on the observations of the contacts at egress made at A. S. Lehman's ranch, in Nevada:

The geographical position of the station occupied was derived from a small triangulation executed for the purpose of connecting the State boundary of Nevada and Utah with Jeff. Davis Peak, a principal station of the geodetic survey of the thirty-ninth parallel of latitude, and the position of which depends upon the Coast Survey telegraphic longitude of San Francisco and several of the astronomical azimuths and latitudes observed in connection with the geodetic survey referred to.

The geodetic positions of Jeff. Davis Peak and the Transit of Venus station as resulting from the field computations are as follows:

	Latitude.	Longitude.
Jeff. Davis Peak	$+38° 59' 03''.00$	$+114° 18' 47''.35$
Transit of Venus station	$+39° 00' 34''.74$	$+114° 11' 04''.59$

These may be regarded as reliable to within about 1″ in latitude and 2″ in longitude. Whatever corrections the final adjustment of the triangulation may yield for the position of Jeff. Davis Peak will apply in like manner to the position of the Transit of Venus station.

The altitude of the latter station above sea-level is 1900 meters nearly.

The contacts were observed with a Steinheil refracting telescope of 5⅝ inches objective, using the full aperture, and a magnifying power of 250 diameters. The excessive glare of the sun's light was screened down to proper intensity by a small piece of "London-smoke" glass attached to the eye-piece. The focal adjustment of the telescope was made with precision by pointings upon the larger planets at night, and again, finally, by pointings upon Venus itself on the day of the Transit. The definition of the telescope thus focused was very satisfactory, notwithstanding the heating of the eye-piece by continued pointing upon the sun. The telescope, although equatorially mounted, was without a driving apparatus. It was kept properly pointed by means of the slow-motion movement worked by hand.

On the morning of the 6th of December the sky was generally clear, yet there hung threatening storm clouds upon the eastern horizon, shutting away from view the sun, and which on that account was never seen until the planet had shifted fully a diameter upon his disk. The atmosphere at this time seemed much disturbed and undulated strongly. Fortunately, as the day advanced matters changed greatly for the better, and by noon, as the great event of the day was rapidly drawing near, all clouds had vanished, leaving nothing but a thin sheet of haze in the southern skies, not dense enough to impair the distinct vision of the sun. At $17^h 15^m$ chronometer time, the final pointing of the telescope was made, and the progress of the Transit uninterruptedly watched until after occurrence of the third contact. There was now almost perfect calm, and as

the boiling of the atmosphere had well nigh entirely ceased the distinctness and steadiness of the images of both the planet and the sun were all that could be wished for. In fact everything seemed to assure complete success. We were ready for the work.

The record times of the several phases noted are the following:

	h. m. s.	
IIId contact.	At 17 17 30.0	contact rapidly nearing.
	18 01.5	doubt—not yet.
	18 08.5	contact, cusps persistently separated.
	18 15.0	contact plainly passed—cusps distinct and steady.

IVth contact. The phases of this last contact were noted as follows, viz:

h. m. s.	
At 17 38 08.0	contact rapidly approaching.
38 30.0	doubt—not yet.
38 36.5	then—last contact.
38 42.5	contact certainly passed; sun's limb undistorted and persistently complete.

This concluded the observations of the contacts at egress, the only ones visible at this station.

The times, as above noted, being in accordance with the face indications of sidereal chronometer Dent 2147, require correction for *error* and rate to reduce them to *local* sidereal time. From star transits, observed with 30-inch meridian telescope, Coast Survey No. 5, set up in the meridian of the equatorial, the error of this chronometer was found to be:

	h. m.		m. s.	
December 3.	At 21 20	face time	=+1 51.20	from 4 stars.
5.	At 23 00	face time	=+1 51.35	from 10 stars.
6.	At 22 15	face time	=+1 51.33	from 9 stars.

The probable uncertainties of these determinations do not exceed about one-tenth of a second. The running of the chronometer, it will be seen, was quite steady; assuming its rate zero and correcting accordingly, and reducing at the same time also to mean time—the local times of the principal phases of the Transit stand as follows:

	Sidereal time. h. m. s.		Mean time. h. m. s.
IIId contact.	17 16 10.2	doubt—not yet	0 14 09.67
	16 17.2	contact	14 16.65
IVth contact.	17 36 38.7	doubt—not yet	0 34 34.82
	36 45.2	contact	34 41.30

It is important to remark that during the critical moments the observer kept his attention steadily fixed upon the progress of the Transit and announced the occurrence of the different phases observed, *viva voce*, to an experienced recorder, Mr. B. Christensen, who noted and recorded the times in accordance with the face indications of the chronometer.

As regards the "black drop" no such phenomenon as it has been pictured by observers of former transits was seen, nor even anything remotely resembling it. On the contrary, the inner contact seemed to come about in a geometrical sort of way without disturbance or surprise, but very slowly. It was surprising to me to find, on examining the record after everything was over, that the lapse of time between the important phases as noted amounted to only about seven seconds, for my impression was that the interval seemed much greater—three times as great. I believe the observation of the contracts to be trustworthy and entitled to confidence. They were made under circumstances quite favorable, especially as regards state of the atmosphere. Only in the matter of screening down the sun's excessive light it was found as the time of inner contact neared that the proper measure had been exceeded by neglecting to make allowance for the lesser intensity of the sun's light at the limb. Unfortunately the peculiar arrangement improvised for screening off the excess of solar light did not permit of correcting the mistake when noticed without hazarding the whole of the observations. Owing to this excess of screening, and

likewise perhaps to the exceeding slowness with which the contacts seemed to come along, it is probable that I was *late* rather than otherwise in judging the moments of contacts. For these reasons it is my judgment, after mature reflection, that the means of the times of *doubt* and *contact* as noted may be regarded as representing more nearly the times of true geometrical contacts than the single *contact* times as actually noted.

In order to ascertain the error of the mean time chronometer 2404, used by Mr. Marr, of my party, the following comparisons with sidereal chronometer Dent 2147 were made:

		h. m. s.		h. m. s.	
December 6:	Sidereal	18 01 21.0	=	1 14 59.25	mean time.
	(No. 2147)	22 56 11.0	=	6 08 58.75	(No. 2404).

The errors of chronometer 2404 on local mean time were therefore respectively $+ 17^m 37^s.2$ and $+ 17^m 35^s.0$. Correcting Mr. Marr's observations accordingly, his contact times expressed in local mean time reduce to the following, viz:

	h. m. s.
IIId contact =	0 14 07.0
IVth contact =	0 34 21.9

Both times several seconds earlier than as observed by myself, presumably in consequence of the inferior telescopic power used by him. Mr. Marr's own report will be found appended.

It may be proper to state in conclusion that the Transit occurred whilst the party was still engaged in packing down camp outfit and instruments from Jeff. Davis Peak and in storing them at Lehman's Ranch, and that the contact observations herein reported did not interfere with nor delay the regular work of the party nor cause extra expenses to the Survey.

The observations were made in conformity with the printed instructions issued by the Transit of Venus Commission as nearly as the means at hand and existing circumstances permitted.

Respectfully submitted by

WILLIAM EIMBECK,
Assistant.

Prof. J. E. HILGARD,
Superintendent United States Coast and Geodetic Survey, Washington, D. C.

LEHMAN'S RANCH, WHITE PINE COUNTY, NEVADA,
December 6, 1882.

DEAR SIR: Observations of the third and fourth contacts of the Transit of Venus were made as follows:

A telescope by Bardon, Paris, of 2⅜ inches aperture and power of 33 diameters was used. The instrument was firmly mounted in the meridian 28 meters north of your equatorial. The instrument remained quite steady during the observations.

Gentle northeasterly breeze. Sun and planet seen through thin haze. Sun's limb slightly wavering. Time of contacts noted by mean time chronometer Dent No. 2404.

Black cambric was used over left eye and the eye-end of the telescope. A medium dark glass allowed good definition without any glare.

	h. m. s.
Time of third contact	12 31 44.5
Apparent middle of planet	12 43 20.0
Time of fourth contact	12 51 59.5

Just before third contact the limb of the planet nearest the sun's limb seemed to have a bright halo. The time of contact was noted when the bright edge of the sun seemed broken. When the planet was about one-third across, the apparent notch in the sun's limb seemed to be round on the edges. When about two-thirds across, that portion of the planet outlined on the sun seemed elliptical in shape.

The time of fourth contact was noted when the indentation in the sun's limb changed from a faint shadow to bright light, the limb of the sun unbroken.

Respectfully,

R. A. MARR, *Aid.*

Mr. EIMBECK.

APPENDIX No. 17.

DETERMINATIONS OF GRAVITY AND OTHER OBSERVATIONS MADE IN CONNECTION WITH THE SOLAR ECLIPSE EXPEDITION, MAY, 1883, TO CAROLINE ISLAND, SOUTH PACIFIC OCEAN.

A Report by E. D. PRESTON.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., August 17, 1883.

DEAR SIR: I have the honor to submit you the following report of my observations in connection with the United States Eclipse Expedition to Caroline Island, and those made for the determination of gravity at different points along the route.

In obedience to your instructions I left Washington February 28, and sailed from New York March 2, arriving at Aspinwall the morning of the 11th. At noon of the 12th we were at Panama, and at 5 p. m. passage was taken on the steamship Bolivia for Callao, Peru, which place was reached on the 19th. Our instruments were here transferred on board the United States man-of-war Hartford, and on the evening of the 22d we set sail for Caroline Island. Between Callao and the island some preliminary computations were made. A list of stars suitable for time observations at either Flint Island or Caroline Island was selected and their constants computed. Pairs of stars were also selected for latitude. On the morning of the 20th of April (twenty-ninth day out from Callao) land was sighted, and in the afternoon of the same day the landing of instruments was begun. On the 23d the transit pier was finished and the instrument in place; but on account of bad weather no observations were made until the following evening, the day of the 24th being employed in erecting the pendulum stand and tents in which it stood. From April 24 to May 9 observing went on regularly when not interrupted by bad weather. Time was determined as early in the evening and late in the morning as possible. The United States Coast and Geodetic Survey yard-pendulum No. 3 was swung between the two time observations, and latitude was determined by the method of equal zenith distances. Gravity was determined on eight nights, six with the heavy end of the pendulum down and two with the same end up. In one of the experiments with heavy end down, however, no time was obtained in the morning. Latitude was determined on five nights, with an average of ten pairs on each night.

The morning of the eclipse (May 6) was cloudy; in fact, it was raining heavily forty minutes before the time of first contact; but fortunately it cleared off very suddenly, giving us a remarkably steady atmosphere, and all four contacts were satisfactorily observed—the last three particularly so. The first was observed by three persons, my own observation falling between the other two; the second and third were only observed by myself, and the fourth was noted by three persons, Mr. Rockwell's observation and mine differing but two-tenths of a second; the former was noted by "eye and ear" method, and the latter on the chronograph. Observing ended May 9 at 6 o'clock a. m., and at 5 p. m. everything was aboard the Hartford and we were under way for Honolulu.

During the passage from Caroline Island to the Sandwich Islands the chronograph sheets were read and the definitive chronometer corrections were deduced by the application of the method of least squares. Apparent places of stars were also computed and most of the pairs worked up for latitude.

On arriving at the Sandwich Islands I received instructions from you to proceed to the island of Maui and to determine the force of gravity at the station occupied by De Freycinet in 1819. We arrived at Lahaina at 1 o'clock a. m., June 6. We discovered the foundation walls of the old brick house located in De Freycinet's sketch, and near which his observatory was erected; thanks to the assistance of Mr. S. E. Bishop, attached to the Hawaiian Government survey, and an old native, Kanaka, who himself had seen the experiments of 1819 made. At Lahaina the pendulum was swung seven nights with heavy end down and three nights with heavy end up, besides one swing at a high temperature. Stars were observed morning and evening as at Caroline Island. Latitude was also determined by observations on thirty-five pairs of stars, extending over eight nights, but not all the pairs were observed on any one night, the total number of measures of the latitude being 114. We desired to fix the position of Lahaina well, because Professor Alexander, superintendent of the Government survey, informed us that he had never had a latitude determined on Maui with the degree of precision attained by the modern method of equal zenith distances, and it is his intention to carry our Lahaina latitude back to Oahu by triangulation and compare it with determinations there made by Captain Tupman, of the British Transit of Venus Expedition of 1874. I have no doubt but that this operation will show a deflection of the plumb line on Maui of at least 8 or 10 seconds. The Pacific Ocean is very deep around the Sandwich Islands and the mountains rise 4,000 feet high immediately back of Lahaina.

Our observations occupied us until the 23d, when we sailed again for Honolulu, arriving at 2 o'clock Sunday morning, the 24th. Before sailing for Maui a place to swing had been selected, and the pier having been erected during our absence no time was lost on our return, and everything was in readiness for the evening of the 25th. Here a slight change was made in the usual programme. Instead of swinging the pendulum from 7 p. m. to 5 a. m., as was done at Caroline Island and at Maui, it was swung continuously from the beginning to the end. There were two reasons for this: In the first place, the occupation of the cellar of the Young Men's Christian Association building gave us a place where the daily variation of temperature was comparatively slight; and, secondly, after arriving at Honolulu only one week remained in which to set up the apparatus, make the experiments, and repack again for shipment. No stars being obtained on the 25th, swinging was begun June 26, after the time determination in the evening, and continued during three consecutive days and nights. Forty-eight hours were given to heavy end down and twenty-four to heavy end up. Stars were obtained after the pendulum observations and each night during their progress. Each night after the time observations, the instrument was turned over to Professor Alexander, who had expressed the desire to make some observations of latitude himself while the instrument was in Honolulu. However, on account of clouds and rain on all of the three nights very few pairs could be obtained.

We sailed from Honolulu on Monday, July 2, arriving in San Francisco the evening of the 9th. At this station we were rather unfortunate both in regard to weather and temperature. Swinging was begun Sunday evening, July 15, and continued without interruption for four days and nights, with heavy end down, before being able to get stars again. The pendulum was then turned from forward to back and swung for twenty-four hours more, time being determined again at the end. From July 21st to 27th no stars could be obtained, and this time was employed in reading sheets and making duplicates of the Lahaina and Honolulu work. On the 27th swinging was again resumed, with heavy end up, and continued for twenty-four hours. Time was determined before and after. The temperature was not very satisfactory; but swinging only during the night could not be done, because it was scarcely ever possible to get stars in the evening and also the following morning. This condition was realized only once during the experiments. From July 29 reading sheets and making duplicates went on without interruption until August 10, when I left for Washington, arriving there on the 16th.

The thermometers were compared at Caroline Island. They were again compared and the zero points of two of them determined on our arrival at Honolulu. This was again done at San Francisco. The barometer was compared before leaving Washington with a standard one, and again in San Francisco.

In the Caroline Islands, and in Maui and Honolulu, I was most efficiently assisted by Ensign

S. J. Brown, U. S. N., who took part in all the observations except those for time. At San Francisco Mr. C. B. Hill took Mr. Brown's place.

In closing this report I desire to express our thanks to Prof. W. D. Alexander, superintendent of the Hawaiian Government survey, for his interest in the work and for his many kindnesses; also to Mr. H. Turton, of Lahaina, who did everything in his power to facilitate the work at that place; and finally to his excellency Governor Dominus, of Oahu, who very kindly placed his summer residence at Lahaina entirely at our disposal during the stay on Maui.

I am, most respectfully, your obedient servant,

ERASMUS D. PRESTON,
Aid United States Coast and Geodetic Survey.

Prof. J. E. HILGARD,
Superintendent United States Coast and Geodetic Survey.

APPENDIX No. 18.

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS. MEAN PLACES FOR 1885.0.

By GEORGE DAVIDSON, Assistant.

The first edition of this working catalogue of Time and Circumpolar stars was published in 1874.* It was the outgrowth of the necessities of those field parties of the United States Coast and Geodetic Survey which were engaged in Geographical Reconnaissance, Telegraphic Longitude, Latitude and Azimuth work, and special investigations demanding the determination of exact local time without the facilities and resources of a fixed Astronomical Observatory. It placed before the observer the Transit Stars of the different National Ephemerides; whilst the long time-intervals between these stars were filled in with stars from Standard Catalogues, so that the intervals of Right Ascension between time stars should not exceed two minutes, if practicable. In addition thereto, circumpolar stars were introduced in the order of their transits above and below the Pole.

This plan has not been changed except to insert additional time stars and especially to increase the number of the azimuth stars.

Within a few years the Ephemerides have notably extended their catalogues of stars. These Ephemerides give the apparent places of the time or clock stars for each tenth or twentieth day; and for every day for some of the close circumpolar stars. In the Standard Catalogues the mean star places only are given for specified epochs antedating their publication.

In order that these and other conditions may be presented clearly to the eye of the observer, the names of all stars for which no apparent places are given in the Ephemerides are printed in italics; the names of the circumpolar stars are denoted by heavier type, and their sub-polar transits indicated by the letters S. P., and also by the retention of the hour of their upper transit in the column of Right Ascensions, and by the Declinations being greater than 90°.

For the epoch 1885.0 the Right Ascensions have been brought up to the nearest tenth of a second of time and the Declinations to the nearest

*U. S. Coast Survey, Field Catalogue of 983 Transit Stars, Mean Places 1870.0. George Davidson, Assistant, Coast Survey, in charge Pacific Coast. Washington: Government Printing Office. 1874.

second of arc. For the tabular declination the natural number of the secant thereof has been given, mainly to enable the observer to calculate with reasonable closeness the times of passage of a slow-moving star at the side threads of the transit reticule.

In the determination of the mean places of the stars, it has been necessary to calculate the Right Ascension and the Declination from two or more Catalogues, to examine the different authorities for the proper motions, or to derive them from the tabulated positions; to compute the annual precession for the slow-moving stars; and thence to derive the annual variations in Right Ascension and Declination.

The number of clock or time stars is 1126, and the number of circumpolar or azimuth stars is 152. There are very few stars so small as the 6–7 magnitudes, and all can be easily observed with the 30-inch portable transit instrument of the Survey.

The magnitudes assigned to the stars have been given according to the old method, but a hyphen has been interplaced instead of a period when the star is considered to be between two whole magnitudes.

The right-hand page has been left partly blank for the insertion of memoranda, also to give space to the observer to note the altitude, or zenith-distance setting for the stars, the chronometer times of transits, &c.

With this working catalogue, and the table of the star factors A, B, C,* for azimuth, inclination, and collimation, the observer in the field, even without a knowledge of the error of his chronometer, will generally have little trouble in placing his transit instrument within one second of time, or less, of the plane of the meridian, in half an hour; and within one-quarter of a second of time, or less, of the meridian in one hour. By using the Davidson Transit and Equal Altitude Instrument,† and the Table of Altitudes and Azimuths of Polaris,‡ the transit instrument may readily be adjusted very closely to the plane of the meridian before sunset.

I have in preparation a list of double stars compiled solely to enable the observer to adjust and test the sidereal focus of his telescope. I have been better satisfied with this method than any other.

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* U. S. Coast Survey, C. P. Patterson, Superintendent. The Star-Factors A, B, C., for Reducing Transit Observations. George Davidson, Assistant, Coast Survey, in charge of Pacific Coast. Washington: Government Printing Office. 1874.

(This publication contains 57,500 factors, computed to three places of decimals for all Latitudes and all Declinations to 80°, and also for special circumpolars. A similar systematic table for stars having greater declination than 80°, is being computed.)

† U. S. Coast and Geodetic Survey, C. P. Patterson, Superintendent. Methods and Results. Description of a New Meridian Instrument, by George Davidson, Assistant, U. S. Coast and Geodetic Survey, Appendix No. 7. Report for 1879. Washington: Government Printing Office. 1881.

‡ [From the U. S. Coast Survey Report, 1879.] Appendix No. 22. Azimuth and Apparent Altitude of Polaris for field use in placing the Meridian Instrument in the Plane of the Meridian. Computed with North Polar Distance of 1° 22′, and Mean Refraction, by George Davidson, Assistant, U. S. Coast Survey.

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

The Ephemerides and Catalogues consulted in the formation of this field list of stars, with the designating letter of each in the column of authorities, are herewith enumerated.

The column of authorities does not necessarily give all those examined, except for such stars as have been less frequently observed in the catalogue to which access was practicable. Preference has been given to the Catalogues A′, N, H, and G.

A.—The American Ephemeris and Nautical Almanac for the year 1885. First edition. Published in compliance with a Joint Resolution of the Forty-sixth Congress. Washington: Bureau of Navigation. 1882.

E.—The Nautical Almanac and Astronomical Ephemeris for the year 1882, for the meridian of the Royal Observatory at Greenwich. Published by order of the Lords Commissioners of the Admiralty. London. Printed by G. E. Eyre & W. Spottiswood Her Majesty's Printers; and sold by John Murray, Albemarle street. 1878.

C.—Connaissance des Temps, ou des mouvements Célestes, à l'usage des Astronomes et des Navigateurs. Pour l'an 1882, publiée par le Bureau des Longitudes. Paris, Gauthier-Villars, Imprimeur-Libraire du Bureau des Longitudes de l'École Polytechnique, Successeur de Mallet-Bachelier, Quai des Augustins, 55. Août 1880.

B.—Berliner astronomisches Jahrbuch für 1883 mit Ephemeriden der Planeten (1) — (217) für 1881. Herausgegeben von der Königlichen Sternwarte zu Berlin unter Redaction von W. Foerster und F. Zietjen. Berlin, Ferd. Dümmlers Verlagsbuchhandlung, Harrwitz und Gossmann, 1881.

A′.—Washington Observations for 1870. Appendix III. On the Right Ascension of the Equatorial Fundamental Stars and the corrections necessary to reduce the Right Ascensions of different Catalogues to a mean homogeneous system. By Simon Newcomb, Professor of Mathematics, U. S. N. Prepared at the U. S. Naval Observatory, by order of Rear-Admiral B. F. Sands, U. S. N., Superintendent. Washington: Government Printing Office. 1872.

N.—Catalogue of 1098 Clock and Zodiacal Stars. Prepared under the direction of Simon Newcomb, Professor, U. S. N., Superintendent American Ephemeris.

H¹.—Annals of the Astronomical Observatory of Harvard College. Vol. IV, Part I. Catalogue of Polar and Clock Stars. Printed from the Sturgis Fund. Cambridge: Welch, Bigelow & Company, Printers to the University. 1863.

H^2.—Annals of the Astronomical Observatory of Harvard College. Vol. X. Observations made with the Meridian Circle during the years 1871 and 1872, under the direction of the late Joseph Winlock, A. M., Phillips Professor of Astronomy and Director of the Observatory. By William A. Rogers, A. M., Assistant Professor of Astronomy in the Observatory. Printed from funds resulting from the will of Josiah Quincy, jr., who died in April, 1775, leaving a name inseparably connected with the history of the American Revolution. Cambridge: Press of John Wilson & Son. 1878.

H^3.—Annals of the Astronomical Observatory of Harvard College. Vol. IV, Part II. Observations in Right Ascension of 505 Stars. Printed from the Sturgis Fund. Cambridge: Press of John Wilson & Son. 1878.

H^4.—Catalogue of 618 Stars observed at the Astronomical Observatory of Harvard College, with the Meridian Circle, during the years 1871–'72, 1874, and 1875, and prepared for publication under the direction of Joseph Winlock and Edward C. Pickering, successive Directors of the Observatory. By William A. Rogers, Assistant Professor of Astronomy in the Observatory. Printed from the Sturgis Fund. Extracted from Volume XII of the Annals. Cambridge: John Wilson & Son. University Press. 1880.

G^1.—Catalogue of 2156 Stars, formed from observations made during twelve years, from 1836 to 1847, at the Royal Observatory, Greenwich. London: Printed by Palmer & Clayton, Crane Court, Fleet street, and sold by J. Murray, Albemarle street. MDCCCXLIX.

G^2.—Catalogue of 1576 Stars, formed from observations made during six years, from 1848 to 1853, at the Royal Observatory, Greenwich, and reduced to the epoch 1850. (Forming Appendix II to the volume of Greenwich Observations for the year 1854.) London: Printed by George Edward Eyre and William Spottiswood, Printers to the Queen's most Excellent Majesty, for Her Majesty's Stationery Office. 1856.

G^3.—Seven-Year Catalogue of 2022 Stars, deduced from observations extending from 1854 to 1860 at the Royal Observatory, Greenwich, and reduced to the epoch of 1860. (Forming Appendix I to the volume of Greenwich Observations for the year 1862.)

G^4.—New Seven-Year Catalogue of 2760 Stars, deduced from observations extending from 1861 to 1867 at the Royal Observatory, Greenwich, and reduced to the epoch of 1864. (Forming Appendix II to the volume of Greenwich Observations for the year 1868.)

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

G[5].—Nine-Year Catalogue of 2263 Stars, deduced from observations extending from 1868 to 1876, made at the Royal Observatory, Greenwich, under the direction of Sir George Biddell Airy, K. C. B., M. A., LL. D., D. C. L., Astronomer Royal. Reduced to the epoch of 1872. (Forming Appendix I to the volume of Greenwich Observations for the year 1876.)

W.—Catalogue of Stars observed at the U. S. Naval Observatory during the years 1845 to 1877, and prepared for publication by Professor M. Yarnall, U. S. N., by order of Rear-Admiral John Rodgers, U. S. N., Superintendent. Second edition, revised and stereotyped. Washington: Government Printing Office. 1878.

O[1].—The Cape Catalogue of 1159 Stars, deduced from observations at the Royal Observatory, Cape of Good Hope, 1856 to 1861, reduced to the epoch of 1860, under the superintendence of E. J. Stone, M. A., F. R. S., F. R. A. S. (late Fellow of Queen's College, Cambridge), Her Majesty's Astronomer at the Cape. Published by order of the Board of Admiralty, in obedience to Her Majesty's command. Cape Town: Saul Solomon & Co., 49 and 50 St. George street. 1873.

O[2].—Results of Astronomical Observations at the Royal Observatory, Cape of Good Hope, during the year 1874, under the direction of Edward James Stone, M. A. Camb., F. R. S., F. R. A. S., C. M. de la Société Nationale des Sciences Naturelles de Cherbourg, Honorary Fellow of Queen's College, Cambridge, and Her Majesty's Astronomer at the Cape of Good Hope. Published by order of the Board of Admiralty, in obedience to Her Majesty's command. Cape Town: Saul Solomon & Co., 49 and 50 St. George street. 1877.

M.—First Melbourne General Catalogue of 1227 Stars, for the epoch 1870, deduced from observations extending from 1863 to 1870, made at the Melbourne Observatory, under the direction of Robert L. J. Ellery, Government Astronomer to the Colony of Victoria. Reduced and prepared for publication by Mr. E. J. White, First Assistant Astronomer. Melbourne: John Ferres, Government Printer. 1874.

B*k*.—Resultate aus Beobachtungen von 521 Bradley'schen Sternen am grossen Berliner Meridiankreise von Dr. E. Becker, erstem Observator der Königlichen Sternwarte zu Berlin. Separat-Abdruck aus den Astronomischen Beobachtungen auf der Königlichen Sternwarte zu Berlin. Berlin, 1871. A. W. Schade's Buchdruckerei (L. Schade), Stallschreiberstrasse, 45 und 46.

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

R*d*.—The Radcliffe Catalogue of 6317 Stars, chiefly circumpolars, reduced to the epoch 1845.0; formed from observations made at the Radcliffe Observatory, under the superintendence of Manuel John Johnson, M. A., late Radcliffe Observer; with introduction, by Rev. Robert Main, M. A., Radcliffe Observer. Published by order of the Radcliffe Trustees. Oxford: J. H. and Jas. Parker. 1860.

R.—Places of 5345 Stars, observed from 1828 to 1854, at the Armagh Observatory. By Rev. T. R. Robinson, D. D., F. R. S., F. R. A. S., &c. Printed at the expense of Her Majesty's Government on the recommendation of the Royal Society. Dublin: Alex. Thorn & Sons, Printers and Publishers, 87 and 88 Abbey street. 1859.

G*i*.—Washington Observations for 1868. Appendix I. A Catalogue of 1963 Stars, reduced to the beginning of the year 1850, together with a Catalogue of 290 Double Stars. The whole from observations made at Santiago, Chili, during the years 1850–'51–'52, by the U. S. Naval Astronomical Expedition to the Southern Hemisphere. Lieut. James M. Gilliss, LL. D., Superintendent; Lieut. Archibald MacRae, Master S. Ledyard Phelps, and Captain's Clerk E. R. Smith, Assistants. Published by the U. S. Naval Observatory, Commodore B. F. Sands, U. S. N., Superintendent. Washington: Government Printing Office. 1870.

W*i*.—Publications of the Washburn Observatory of the University of Wisconsin. Vol. I. Madison: David Atwood, State Printer. 1882.

S^1.—Catalogue of the Mean Declinations of 981 Stars, between twelve hours and twenty-six hours of Right Ascension, and 30° and 60° of North Declination, for January 1, 1875. Prepared under the direction of Bvt. Brig. Gen. C. B. Comstock, U. S. A., Major Corps of Engineers, in charge of the U. S. Lake Survey. By Professor T. H. Safford, Director of Dearborn Observatory. Washington: Government Printing Office. 1873.

S^2.—Engineer Department, United States Army. Catalogue of the Mean Declinations of 2018 Stars, between 0^h to 2^h and 12^h to 24^h Right Ascension, and 10° and 70° of North Declination, for January 1, 1875. Prepared under direction of First Lieut. Geo. M. Wheeler, Corps of Engineers, U. S. A., in charge of U. S. Geographical Surveys West of 100th Meridian. By T. H. Safford, Ph. D., Field Memorial Professor of Astronomy in Williams College, Massachusetts. Washington: Government Printing Office. 1879.

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

W[2].—Astronomical and Meteorological Observations made during the year 1878, at the United States Naval Observatory. Rear-Admiral John Rodgers, U. S. N., Superintendent. Published by authority of the Honorable Secretary of the Navy. Washington: Government Printing Office. 1882.

B′.—Mittlere und scheinbare Oerter für das Jahr 1882.0 von 539 Sternen des Verzeichnisses I und II, welche nach der Vierteljahrsschrift der "Astronomischen Gesellschaft," IV. Jahrgang, 4. Heft 1869, für die Beobachtung der Sterne der nördlichen Halbkugel bis zur neunten Grösse als Grundlage dienen soll. Unter Mitwirkung der "Astronomischen Gesellschaft" herausgegeben von der Redaction des Berliner Astronomischen Jahrbuchs. Berlin, Ferd. Dümmlers, Verlagsbuchhandlung, Harrwitz & Gossmann. 1877.

The work upon this Catalogue has been done at intervals independently of the regular duties of the Survey, and consequently it has been a long time in hand.

GEORGE DAVIDSON.
Assistant Coast and Geodetic Survey.

DAVIDSON OBSERVATORY,
San Francisco, Cal., May 9, 1883.

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
1	*Groom.* 4233	6–5	0 00 28.2	+3.081	+ 63 33 23	+20.07	2.51
2	α Andromedæ	2	02 26.7	3.090	+ 28 27 20	19.89	1.04
3	β Cassiopeiæ	2–3	03 02.6	3.170	+ 58 30 55	19.85	1.91
4	22 Andromedæ	5–6	04 20.7	3.300	+ 45 25 55	20.04	1.43
5	θ *Sculptoris*	5	0 05 53.1	3.057	− 35 46 37	20.14	1.23
636	4 **Draco.**, S. P.	5–4	12 06 48.3	+2.891	+101 44 41	+20.02	4.91
6	γ Pegasi	3–2	0 07 18.9	3.083	+ 14 32 39	20.03	1.03
7	35 *Piscium*	6	09 03.5	3.087	+ 8 10 56	20.01	1.01
8	**Groom. 29**	6–7	09 56.5	3.300	+ 76 20 12	20.01	4.23
9	θ *Andromedæ*	5–4	11 05.2	3.120	+ 38 02 36	20.02	1.27
10	σ Andromedæ	4–3	0 12 19.3	+3.121	+ 35 08 51	+19.99	1.22
644	5 ***Urs. Min., S. P.***	6	12 13 29.4	1.831	+ 92 55 30	20.02	19.60
11	ι Ceti	3–4	0 13 34.0	3.053	− 9 27 43	19.96	1.01
646	6 **Urs. Min.**, S. P.	6	12 14 18.8	0.081	+ 91 39 45	19.95	34.47
12	d *Piscium*	6–5	0 14 40.8	3.084	+ 7 33 05	20.03	1.01
13	ι *Sculptoris*	5	15 44.5	+3.021	− 29 50 59	+19.98	1.15
14	12 *Cassiopeiæ*	6–5	18 27.1	3.269	+ 61 11 39	19.98	2.08
15	44 Piscium	6	19 30.4	3.073	+ 1 18 10	19.96	1.00
16	β Hydri	3	19 41.4	3.238	− 77 54 07	20.29	4.77
17	***B. A. C. 86***	6	19 46.4	3.702	+ 79 24 55	19.95	5.44
18	45 *Piscium*	6	19 46.2	+3.088	+ 7 03 20	+19.96	1.01
19	α Phœnecis	2	0 20 35.7	2.978	− 42 55 54	19.61	1.37
20	10 *Ceti*	6	20 43.5	3.075	− 0 41 12	19.98	1.00
21	*B. A. C.* 100	5–6	22 02.6	3.191	+ 43 45 31	19.96	1.38
22	*B. A. C.* 103	5–6	22 13.5	2.980	− 33 38 31	19.90	1.20
23	12 Ceti	6	24 10.2	+3.061	− 4 35 34	+19.94	1.00
24	κ Cassiopeiæ	4–5	0 26 28.1	3.366	+ 62 17 44	19.94	2.15
659	κ **Draco.**, S. P.	3–4	12 28 34.3	2.594	+109 34 40	19.89	2.98
25	13 Ceti	6–5	0 29 19.7	3.086	− 4 13 34	19.86	1.00
26	ζ Cassiopeiæ	4	30 34.2	3.314	+ 53 15 49	19.86	1.67
27	π Andromedæ	4	30 44.4	+3.189	+ 33 5 10	+19.88	1.20
28	***Groom. 100***	6	31 08.4	4.286	+ 81 51 25	19.85	6.58
29	B. A. C. 160	5–6	31 25.8	3.086	− 25 24 03	19.87	1.11
30	ε Andromedæ	4	32 28.8	3.159	+ 28 41 14	19.61	1.14
31	δ Andromedæ	3–4	33 10.7	3.194	+ 30 13 53	19.74	1.16

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
$G^{5.1}$ R. S^{2}	1	10 Cassiopeiæ.	
A^{1} E. C. B. N. $H^{4.2.1}$.	2		
A. C. B. $G^{5.3.2.1}$ . .	3		
A. B. G^{3} $H^{4.2}$ G^{3} . .	4		
W. M..	5		
A. B. N. $H^{4.3.2}$ . .	636		
A. E. C. B. N. H. .	6	C = 2 mag. [— 10″.4.	
N. $H^{4.2}$ $G^{3.1}$ W. . .	7	2d ✱ 7½, mag.: $+0^{s}.40$	
B. H^{4} $G^{5.4.3}$ W. . .	8	Brad. 6; mag. 5–6 = G^{5}.	
$H^{4.2}$ $G^{5.2}$ W. $S^{2.1}$ . .	9		
A. $G^{5.4}$ W. R. . .	10		
$G^{2.1}$ $H^{3.1}$ W. Bk. . .	644		
A. E. B. $H^{4.2}$ $G^{5.4}$.	11		
A. C. $H^{3.1}$ $G^{5.4.3.2.1}$.	646		
$G^{4.3.1}$ N. W. O^{1} R. .	12		
$H^{4.3.2.}$ G^{4-1} W. . .	13		
$H^{4.2}$ $G^{5.3.1}$ R. S^{2} . .	14		
A. N. $G^{5.4.3.1}$ W. . .	15		
A. E. N. $O^{2.1}$ M. . .	16		
$G^{5.4.3.1}$ Rd. R.. . .	17	Brad. 24.	
N. $G^{5.4.1}$ W. O^{1} R. .	18		
C. H. W. O^{1} M. . .	19		
N. $G^{5.4.3.2.1}$ R.. . .	20		
R. $S^{2.1}$	21		
G^{3} $H^{4.2}$ W. M. . .	22		
A. E. C. B. N. $G^{5.4.3.2.1}$.	23		
B. $H^{4.2.1}$ $G^{5.4.3.2.1}$ W. R..	24		
A. B. N. $H^{4.3}$ $G^{5.4.3.2.1}$.	659		
C. N. H^{2} $G^{5.4.3.2.1}$ W..	25		
B. H^{3} $G^{5.2.1}$ W. R. .	26		
A. B. $G^{5.3.1}$ W. R.. .	27	Comp. 9 mag.; 36″.	
H^{3} G^{5} W. Rd. R. .	28		
C. $H^{4.2}$ G^{1} W. R.. .	29	C = Piazzi 0^{h} 130.	
B. $G^{5.4.3.2.1}$ W. O^{2} R. .	30		
B. $G^{5.2.1}$ W. R. S^{2} . .	31		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
32	α Cassiopeiæ	2–3	0 33 59.2	+3.371	+ 55 54 23	+19.79	1.78
33	ξ *Cassiopeiæ*	6–5	35 39.0	3.318	+ 49 52 55	19.79	1.55
34	β Ceti	2	37 49.0	3.014	— 18 37 05	19.81	1.06
35	**21 Cassiopeiæ**	6	38 03.9	3.850	+ 74 21 33	19.76	3.71
36	ο Cassiopeiæ	5	38 19.2	3.316	+ 47 39 17	19.76	1.48
37	*B. A. C.* 205	6	0 39 32.8	+3.056	— 5 15 39	+19.69	1.00
38	ζ Andromedæ	4	41 14.7	3.171	+ 23 38 29	19.62	1.09
39	η Cassiop. (pr.)	4–3	42 08.6	3.583	+ 57 12 20	19.23	1.85
40	189 Piazzi, 0ʰ	6	42 20.8	3.131	+ 4 41 20	18.53	1.00
41	δ Piscium	4–5	42 43.0	3.107	+ 6 57 32	19.66	1.01
42	ν Andromedæ	4	43 28.3	+3.289	+ 40 27 09	+19.69	1.31
43	Brad. 82	6	43 45.3	3.579	+ 63 37 16	19.67	2.25
44	*B. A. C.* 237	6	45 23.0	3.086	+ 2 45 40	19.59	1.00
45	20 *Ceti*	5	0 47 07.8	3.063	— 1 46 08	19.65	1.00
673	**32 Camel.fol. S.P.**	5–4	12 48 17.5	0.383	+ 95 57 43	19.60	9.63
46	γ Cassiopeiæ	2	0 49 46.3	+3.574	+ 60 05 38	+19.57	2.01
47	μ Andromedæ	4	0 50 22.1	3.309	+ 37 52 31	19.63	1.27
678	**8 Draco., S. P.**	5	12 50 53.8	2.413	+113 56 15	19.61	2.46
48	*h Piscium* 68	6	0 51 36.7	3.234	+ 28 22 13	19.54	1.14
49	***B. A. C. 240***	6–7	51 57.2	13.987	+ 88 24 23	19.48	35.96
50	α *Sculptoris*	5–4	53 04.8	+2.893	— 29 58 47	+19.51	1.15
51	**43 Cephei**	4–5	53 11.5	7.132	+ 85 38 23	19.52	13.15
52	*Weiss* 0ʰ, 1371	6–7	55 30.6	3.219	+ 24 40 37	19.47	1.10
53	ε Piscium	4	56 58.5	3.109	+ 7 16 15	19.50	1.01
54	72 *Piscium*	6	0 59 01.1	3.159	+ 14 19 38	19.47	1.03
55	μ Cassiopeiæ	5–6	1 00 37.5	+3.950	+ 54 21 23	+17.78	1.72
56	**44 Cephei**	6–5	02 22.4	4.955	+ 79 03 40	19.30	5.30
57	ε *Piscium*	6–5	02 26.6	3.085	+ 5 02 28	19.13	1.00
58	η *Ceti*	3	02 48.6	3.020	— 10 47 30	19.19	1.02
59	β Andromedæ	2–3	03 17.7	3.343	+ 35 00 37	19.17	1.22
60	τ Piscium	4	03 17.7	+3.344	+ 32 52 18	+19.20	1.19
61	χ *Piscium*	5–4	1 05 16.4	+3.217	+ 20 25 23	19.24	1.07
687	***Gr. 2006, S. P.***	7	13 06 47.6	—9.621	+ 91 44 01	19.23	33.06
62	*B. A. C.* 362	6–7	1 06 57.1	+2.830	— 31 24 42	19.07	1.17
63	37 *Ceti*	6–5	1 08 36.5	+3.019	— 8 32 27	19.50	1.01

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. E. C. B. N. $H^{4.3.2.1}$.	32	Mag. 2¼ to 2¾. Per. irr.	
$H^{4.2}$ $G^{5.4}$ R. $S^{2.1}$ . .	33		
A. E. C. B. N. $H^{4.3.2.1}$.	34		
A. B. N. $H^{4.2.1}$ $G^{5.4}$ W.	35		
A. B. G^4 R. . . .	36		
R.	37	Piaz. 0^h, 171.	
B. $H^{4.2}$ $G^{5.3.2.1}$ W. .	38	$G^4 = 6$ mag.	
B. $H^{4.3.2}$ $G^{5.4.3.2.1}$ W. .	39	$\eta^2 = 7\frac{1}{2}$ mag.: $+0^s.9$: $-3''.4$. Period 222 years.	
C. N. $G^{5.4.1}$ W. R. .	40	B. A. C. 221.	
A. E. C. B. N. H^3 $G^{5.1}$	41		
C. $H^{4.2}$ $G^{5.1}$ W. R. S^2 .	42	W. B. (2)O^1, 1062, 7–8 mag.: [$-32^s.1+9''.6$ G^5	
B. Bk. G^1 R. . . .	43		
N. H^4 G^5 W. R. . .	44	$R = 7\frac{1}{2}$ mag.	
N. $H^{4.2}$ $G^{5.4.3.2.1}$ W. .	45		
A. N. $H^{3.2}$ $G^{5.4.2.1}$ W. .	673	Pr. ✱=5 mag.: 6½ mag.: [$-7^s.95$: $+17''9$: G^5 1872.	
A. C. B. $H^{4.3.2.1}$ $G^{5.3.2.1}$	46		
A. B. H^3 $G^{5.4}$ W. S^2 .	47	Comp. ✱=16 mag.: [$+3^s.1$ -- $19''$: requires 6-in.	
B. H^4 $G^{4.3}$ W . . .	678		
$G^{5.4}$ R. S^2	48		
$G^{5.2}$ Rd. R. . . .	49		
$H^{4.3.2}$ $G^{3.1}$ W. O^1 . .	50		
A. B. H^1 $G^{5.1}$ W. R .	51	2 Urs. Min.	
H. R. S^2	52		
A. E. C. B. $H^{4.3.2.1}$.	53		
N. $G^{5.4}$ R. S^2 . . .	54		
C. $H^{4.2}$ $G^{5.3.1}$ R. S. .	55	Very large μ and μ'.	
B. $H^{4.3}$ $G^{5.4}$ Rd. . .	56	Brad. 117.	
N. $G^{5.4.3.2.1}$ W. O^1 R. .	57		
B. $G^{5.4}$ W. . . .	58		
A. E. C. B. N. $H^{4.3.2}$.	59		
B. $H^{4.2}$ $G^{5.4}$ R. . .	60	S^2 has not got this star.	
H^2 G^3 W. Rd. R. . .	61		
G^3 Rd. R.	687		
M.	62		
$H^{4.2}$ G^1 Bk. R. . .	63	Comp. 7½ mag.: 51″.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
64	39 *Ceti*	6	1 10 43.0	+ 3.046	− 3 06 10	+19.09	1.00
65	*f* Piscium. . .	5	11 52.0	3.089	+ 3 00 31	19.05	1.00
66	κ Tucanæ. . .	5	11 52.1	2.057	− 69 29 13	19.18	2.85
67	φ *Cassiopeiæ* . .	5–6	12 51.3	3.727	+ 57 37 35	19.04	1.87
68	υ Piscium. . .	4	13 08.8	3.284	+ 26 39 34	19.05	1.12
69	ξ *Andromedæ* .	5–4	15 34.2	+ 3.506	+ 44 55 32	+18.96	1.41
70	α **Urs. Min.** . .	2	16 35.8	22.048	+ 88 41 44	18.97	43.93
71	ψ **Cassiopeiæ** .	5	17 49.2	4.158	+ 67 31 45	18.92	2.62
72	θ′ Ceti	3	18 16.5	2.997	− 8 46 39	18.68	1.01
73	δ Cassiopeiæ . .	3	1 18 18.1	3.879	+ 59 38 14	18.86	1.98
699	***Gr. 2007, S. P.*** .	7–6	13 19 19.6	− 2.500	+ 94 38 40	+18.87	12.35
74	ω *Andromedæ* .	5	1 20 46.6	+ 3.564	+ 44 48 45	18.74	1.41
75	**38 Cassiopeiæ** .	6–7	1 22 41.0	4.371	+ 69 40 20	18.69	2.88
703	**Gr. 2001**, S. P.	6	13 23 12.1	1.518	+107 00 40	18.77	3.42
76	A *Androm.* 49 .	6–5	1 23 12.4	3.573	+ 46 24 50	18.72	1.45
77	γ *Phœnicis* . .	3–4	23 22.2	+ 2.611	− 43 54 26	+18.58	1.39
78	η Piscium. . .	4–3	25 19.8	3.202	+ 14 45 09	18.67	1.04
79	*B. A. C.* 466 .	5–6	27 47.5	2.699	− 37 27 24	18.52	1.26
80	**40 Cassiopeiæ** .	. .	29 20.6	4.670	+ 72 27 12	18.54	3.32
81	50 Andromedæ .	4	30 03.0	3.502	+ 40 49 48	18.16	1.32
82	51 Andromedæ .	4–5	30 56.2	+ 3.652	+ 48 02 42	+18.37	1.50
83	π Piscium. . .	6–5	31 00.2	3.174	+ 11 33 11	18.54	1.02
84	α Eridani . . .	1	33 25.5	2.233	− 57 49 17	18.37	1.88
85	τ *Andromedæ* .	5	33 47.6	3.523	+ 39 59 39	18.34	1.30
86	**43 Cassiopeiæ** .	6	1 33 50.1	4.359	+ 67 27 39	18.40	2.61
715	**Gr. 2029**, S. P.	6	13 34 25.3	+ 1.432	+108 10 21	+18.37	3.21
87	ν Piscium. . .	5–4	1 35 26.8	3.117	+ 4 54 19	18.34	1.00
88	φ Andromedæ .	4	36 27.4	3.733	+ 50 06 31	18.28	1.56
89	*B. A. C.* 527 .	6	36 58.0	2.745	− 32 54 23	18.31	1.19
90	τ Ceti	3–4	38 43.5	2.784	− 16 32 37	19.08	1.04
91	ο Piscium. . .	4–5	39 19.3	+ 3.162	+ 8 34 42	+18.23	1.01
92	ε Sculptoris . .	5	40 15.7	2.819	− 25 37 37	18.18	1.11
93	*B. A. C.* 544 .	6–7	41 51.7	3.521	+ 37 22 47	18.12	1.26
94	χ *Ceti*	5–4	1 43 56.3	+ 2.943	− 11 15 20	17.93	1.02
723	***Gr. 2063, S. P.*** .	6	13 45 38.9	− 2.037	+ 96 40 13	18.01	8.61

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
G^{4} W. R.	64		
A. N. $G^{5.4.3.2}$ W. R. .	65	[− 13ˢ.0 − 1′ 25″ (1875).	
A. O^{1} M.	66	Pr. ∗ — 7½ mag.:	
$G^{2.1}$ Bk. R. S. . .	67		
B. G^{5} R. S^{2} . . .	68		
H^{2} $G^{5.4}$ W. R. $S^{2.1}$.	69	[−27ˢ.1 : −16″.1.	
A. E. C. B. N. $H^{4.3.1}$	70	Comp. = 9½ mag.:	
B. $H^{4.2}$ $G^{5.4.3.2.1}$ Rd. .	71	Test for 2 inch.	
A. E. C. B. N. H^{4-1} G^{5}	72	R = double : 6′.	
C. B. $G^{5.2.1}$ W. R. S^{2} .	73		
$H^{3.1}$ $G^{5.4.3.2.1}$ W. Rd. .	699	Less than 7 mag.: D.	
$H^{4.2}$ G^{1} Bk. R. $S^{2.1}$.	74		
A. N. $H^{4.2}$ $G^{5.4.2}$ R. .	75		
B. H^{4} $G^{4.3}$ W. . .	703		
H^{2} $G^{5.4}$ R. S. . . .	76		
O. M^{1}	77		
A. E. C. B. N. $H^{4.3.2.1}$	78		
$H^{4.2}$ W.	79		
B. $G^{5.4.3.1}$ Rd. . . .	80		
A. $G^{5.4.3.1}$ W. R. S. .	81	v Androm. = Am. Eph.	
B. $H^{4.3.2}$ $G^{5.4.3.2.1}$ W. R.	82	B = v Persei.	
A. N. $G^{5.4.3.2.1}$ W. O^{1}.	83		
A. E. C. N. O. M. .	84	Pr. ∗ = 7 mag.: — 3″.	
$H^{4.2}$ $G^{5.4}$ W. R. . .	85		
B. H^{4} $G^{5.3.2}$ W. . .	86	$G^{4} = \omega$	
B. H^{4} G^{5}	715		
A. E. C. B. N. $H^{4.3}$.	87		
C. B. $G^{5.4.3.2.1}$ R. S^{2} .	88		
W. $G^{3.2.1}$	89	Piaz. I. h 157.	
B. H^{3} $G^{5.4.3.2}$ W. R. .	90		
A. E. C. B. N. $H^{3.2}$ G^{5}	91	[+ 0ˢ.49 + 2″.05, 1870.	
C. B. $G^{2.1}$ W. O^{1} . .	92	Comp. = 10 mag.:	
$H^{4.2}$ $G^{5.4}$ W. R. $S^{2.1}$.	93	Piaz. I, 170.	
$H^{4.2}$ $G^{5.4.2.1}$ W. . .	94		
H^{3} $G^{5.4}$ Rd. . . .	723		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
95	ζ Ceti	3	1 45 47.1	+2.962	− 10 54 12	+17.84	1.02
96	ε Cassiopeiæ	3–4	46 07.9	4.255	+ 63 06 11	17.95	2.20
97	α Trianguli	4–3	46 31.6	3.407	+ 29 01 05	17.83	1.14
98	γ Arietis	4–3	47 13.2	3.280	+ 18 43 46	17.82	1.06
99	ξ Piscium	4	1 47 36.1	3.100	+ 2 37 10	17.82	1.00
726	**i Draconis**, S. P.	5	13 48 04.4	+1.751	+114 42 30	+17.88	2.39
100	β Arietis	3.	1 48 17.3	3.303	+ 20 14 43	17.74	1.07
101	56 *Andromedæ*	5–6	49 19.6	3.545	+ 36 41 13	17.86	1.25
102	λ′ *Arietis*	5–4	51 31.3	3.330	+ 23 03 45	17.70	1.09
103	*B. A. C.* 607	6–7	53 12.7	3.327	+ 20 29 59	17.56	1.07
104	**50 Cassiopeiæ**	4	53 37.8	+5.002	+ 71 51 51	+17.66	3.21
105	υ Ceti	4	54 35.2	2.828	− 21 38 09	17.58	1.08
106	α *Hydri*	3	55 08.8	1.895	− 62 07 47	17.54	2.14
107	α *Piscium*	4	56 05.9	3.102	+ 2 12 28	17.51	1.00
108	γ^1 Andromedæ	2–3	56 50.4	3.657	+ 41 46 38	17.46	1.34
109	*Weisse Ih*, 1017.	6–7	1 58 35.5	+2.926	− 12 24 39	+17.43	1.02
738	**α Draconis**, S. P.	3–4	14 01 16.6	1.623	+115 04 28	17.30	2.36
110	α Arietis	2	2 01 41.5	3.370	+ 22 55 05	17.19	1.09
111	β Trianguli	3	02 42.1	3.552	+ 34 26 33	17.22	1.21
112	***Groom. 454.***	6–7	02 46.1	5.374	+ 73 29 10	17.24	3.52
113	15 *Arietis*	6	04 15.3	+3.316	+ 18 57 25	+17.14	1.06
114	**55 Cassiopeiæ**	6	05 28.2	4.631	+ 65 59 03	17.11	2.46
115	6 Persei	6–5	05 57.6	3.956	+ 50 31 50	16.90	1.57
116	ξ′ Ceti	4–5	06 54.3	3.174	+ 8 18 24	17.04	1.01
117	μ Fornacis	5	2 07 50.5	2.640	− 31 15 52	16.94	1.17
744	**4 Urs. Min.**, S. P.	5	14 09 18.8	−0.334	+101 55 02	+16.91	4.84
118	δ *Trianguli*	6–5	2 10 02.1	+3.647	+ 33 44 51	16.68	1.20
119	γ Trianguli	4–5	10 28.7	3.549	+ 33 18 52	16.87	1.20
120	67 Ceti	6	11 14.8	2.989	− 6 57 10	16.75	1.01
121	θ Arietis	6–5	11 43.8	3.327	+ 19 22 05	16.82	1.06
122	ο Ceti	Var.	13 32.2	+3.026	− 3 30 00	+16.52	1.00
123	*B. A. C.* 727	6	15 41.1	3.721	+ 40 52 26	16.56	1.32
124	κ *Fornacis*	6–5	17 17.2	2.755	− 24 20 19	16.48	1.10
125	ξ *Arietis*	5–6	18 39.2	3.208	+ 10 05 21	16.48	1.02
126	ι **Cassiopeiæ**	4	2 19 35.8	4.856	+ 66 53 04	16.45	2.55

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. B. $H^{4.2}$ $G^{5.2}$ W. .	95		
B. $G^{5.2}$ W. Rd. R. .	96		
B. $G^{5.2.1}$ W. R. S^{2} .	97	[+ $0^{s}.1$: − 8″ Double ✱; 2d = 4 mag.:	
B. $G^{4.3.1}$ W. R. . .	98		
B. $G^{5.4.1}$ W. M. R. .	99		
B. $H^{4.3}$ $G^{5.3.1}$ W. . .	726		
A. E. C. B. N. $H^{3.1}$ $G^{5.4}$	100		
$G^{5.4}$ W. R. Bk. . .	101		
$H^{4.2}$ $G^{5.4}$ W. R. S^{2} .	102	[+ $2^{s}.0$; yl. bl. λ^2 = 8½ mag.:	
G^{3} W. O^{1} R. S^{2} . .	103	Piaz. I, 222.	
A. B. N. $H^{4.3.2}$ G^{5} .	104		
B. $H^{4.3}$ G^{3} R.. . .	105		
O^{1} M. Gi.. . . .	106		
H^{3} $G^{5.4.2}$ W. Rd. R. .	107	[$0^{s}.3$, 1″.3; G^{2} gr. bl. As one mass. Diff. R. A.,	
A. B. $H^{4.3.2}$ $G^{5.4.3.1}$ W.	108	γ^2 = 5 mag. = 9 mag. $G^{1.4}$: [+ $0^{s}.93$ + 4″.7 (1864.). [Comp. close double; 8 in.	
. . . .	109	Lalande 3837.	
A. E. C. B. N. $H^{4.3.2}$.	738		
A′. E. C. B. N. $H^{4.2.1}$.	110		
A. B. $H^{4.2}$ $G^{5.4.3.2.1}$ W..	111		
H^{3} G^{5} Rd. . . .	112		
N. $G^{5.4.3}$ W. R. . .	113		
B. $H^{4.2}$ $G^{5.4.1}$ Rd. R. .	114		
B. $H^{4.2}$ $G^{5.4.3}$ Rd. R. .	115		
A. N. H^{2} $G^{5.4.3.2.1}$ W. .	116		
C. B. G^{2} O^{1} . . .	117		
A. B. H^{4} $G^{5.2}$ W. Bk.	744		
H^{2} $G^{5.3}$ R. . . .	118		
A. B. $H^{4.2}$ G^{4} W. .	119		
A. E. C. B. $H^{4.3.2.1}$.	120		
B. N. $G^{5.4.3.1}$ W. O^{1} .	121		
C. B. $H^{4.3.2}$ $G^{4.3}$ W. .	122	[“Very full sanguine.” [G^{4}. See note in B. A. C. Mag. 1¾ to 9½. Per. 331 d.	
$G^{5.4}$ Rd. R. . . .	123	Groom. 504 = 7.4 mag.: [+ $2^{s}.6$ + 4′ 47″.	
H^{2} $G^{2.1}$ W. . . .	124		
N. $G^{5.4.3.2.1}$ W. O^{1} R. .	125	[+ $1^{s}.30$: — 2″.0, G^{5}, 1872.	
A. B. N. $H^{4.3.2}$ $G^{5.4.3}$.	126	Fol. ✱ = mag.: [Trip., 4½, 7, 9; 1″.8, 7″.8.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
127	δ Hydri	4	2 19 42.6	+1.053	− 69 10 58	+16.46	2.81
128	ρ *Ceti*	5	20 23.7	2.900	− 12 48 33	16.39	1.02
129	*c* *Trianguli*	6–5	21 25.5	3.502	+ 29 09 20	16.56	1.15
130	ξ² Ceti	4	22 02.7	3.183	+ 7 56 38	16.31	1.01
131	27 *Arietis*	6–5	24 31.7	3.319	+ 17 11 40	16.11	1.05
132	σ *Ceti*	4–5	26 38.2	+2.841	− 15 44 54	+16.10	1.04
133	**36 Cassiop.**	6–5	2 27 07.2	+5.574	+ 72 18 51	16.08	3.29
760	**5 Urs. Min.** S. P.	5–4	14 27 46.8	−0.195	+103 47 34	16 01	4.19
134	*B. A. C.* 788	6	2 28 18.6	+2.489	− 35 09 26	15.95	1.24
135	Piazzi II h. 123.	6–7	29 46.4	3.280	+ 6 20 12	17.25	1.01
136	ν *Ceti*	5	29 50.2	+3.137	+ 5 05 28	+15.89	1.00
137	***Groom. 527***	6	31 17.3	8.249	+ 80 57 32	15.84	6.36
138	81 *Ceti*	5–6	31 54.2	3.022	− 3 53 39	15.82	1.00
139	ν Arietis	6–5	32 17.2	3.396	+ 21 27 49	15.78	1.07
140	δ Ceti	4	33 35.3	3.072	− 0 10 06	15.72	1.00
141	μ Hydri	6	34 07.7	−1.455	− 79 36 39	+15.67	5.55
142	**Brad. 366**	7–6	34 56.7	+5.073	+ 7 20 06	15.61	2.60
143	μ *Arietis*	6–5	35 53.0	3.372	+ 19 31 14	15 54	1.06
144	θ Persei	4	36 20.9	4.066	+ 48 44 28	15.49	1.52
145	35 Arietis	5	36 42.3	3.504	+ 27 13 01	15.54	1.13
146	γ² Ceti (foll.)	3–4	37 20.5	+3.103	+ 2 45 02	+15.35	1.00
147	π Ceti	4	38 41.0	2.851	− 14 21 49	15.43	1.03
148	μ Ceti	4	38 43.5	3.234	+ 9 37 39	15.40	1.02
149	τ *Eridani*	4–5	39 44.2	2.798	− 19 03 36	15.40	1.06
150	39 *Arietis*	4–5	41 03.5	3.550	+ 28 46 08	15.31	1.14
151	η Persei	4–3	42 18.8	+4.335	+ 55 25 02	+15.20	1.76
152	41 Arietis	4	43 12.9	3.516	+ 26 47 08	15.07	1.12
153	σ Arietis	6–5	45 08.6	3.304	+ 14 36 27	15.03	1.03
154	τ² Eridani	5–4	45 39.3	2.718	− 21 29 44	15.01	1.07
155	τ Persei	4	46 06.4	4.216	+ 52 17 26	15.07	1.63
156	*B. A. C.* 897	6	48 47.5	+4.026	+ 46 41 09	+14.86	1.46
157	η Eridani	3	50 48.5	2.927	− 9 21 24	14.49	1.02
158	**47 Cephei**	6–5	2 50 50.6	+7.688	+ 78 57 45	14.75	5.22
786	β **Urs. Min.** S. P.	2	14 51 02.9	−0.035	+105 23 26	14.72	3.77
159	4 *Eridani*	5–6	2 52 16.9	+2.666	− 24 19 23	14.58	1.10

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. O^1	127		
G^4 R.	128		
$G^{5.4.1}$ W. Bk. R. . .	129		
A. E. C. B. N. $H^{4.3.2.1}$.	130		
N. $H^{4.2}$ $G^{5.3.1}$ W. . .	131		
$H^{4.2}$ $G^{4.1}$ W. O^1 Rd. R.	132		
B. $H^{4.3}$ G^3 Rd. R.. .	133		
A. N. $H^{4.2}$ $G^{5.4.2.1}$ . .	760		
. . . .	134		
C. $G^{5.3.2.1}$ W. R. . .	135		
H^2 $G^{5.4.3.2.1}$ W. O^1 R. .	136	[Easy in 5½-inch. [+0″.5 : yel. bl. Comp. = 15 mag. : $+0^s.40$:	
H^1 $G^{3.2.1}$ Bk. Rd. R. .	137	Brad. = 344.	
G^4 W. R.	138		
B. N. $H^{4.2}$ $G^{5.4.3.1}$ W. .	139		
A. B. $H^{4.2}$ $G^{5.4.3.2}$ W. .	140		
A. M.	141		
B. H^4 $G^{4.3}$ W. Rd. .	142	Groom. 537. Rd. = 5½ mag.	
N. $G^{5.2.1}$ W. O^1 R. .	143		
A. B. $H^{4.2}$ $G^{5.2.1}$ R. .	144		
B. $G^{5.3.2}$ R, . . .	145		
A. E. C. B. N. $H^{4.3.2.1}$.	146	[$-0^s.10$: $+1''.9$: $G^5$1872 : N = γ : γ^1 = 7 mag. : [yel. bl.	
B. G^2 W. Bk. R . .	147		
B. N. $G^{5.4}$ W. O^1 . .	148		
$H^{4.2}$ G^3 Rd. R. . .	149		
$G^{5.1}$ R..	150		
B. $G^{5.2.1}$ W. Rd. R. .	151		
C. B. $H^{4.3.2}$ $G^{5.4.3.2.1}$.	152		
A. E. N. $G^{5.4.3.2.1}$ W. .	153		
B. G^3 Rd. R. . . .	154		
B. $H^{4.2}$ $G^{5.1}$ W. Rd. R.	155		
G^4 Rd..	156		
B. $H^{3.2}$ $G^{5.2}$ W. R. .	157		
A. B. $H^{4.2}$ $G^{5.4.2}$ W. .	158	Brad. = 392.	
A. E. C. B. N. $H^{4.3.2.1}$.	786		
$G^{2.1}$ W. Bk. R. . .	159	W. = 7–6 mag.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
160	ε Arietis	4–5	2 52 38.2	+3.420	+ 20 52 47	+14.63	1.07
161	λ *Ceti*	4–5	53 33.2	3.214	+ 8 26 55	14.54	1.01
162	θ *Eridani* (*pr.*)	4–5	2 53 54.0	2.274	— 40 45 56	14.63	1.32
790	**2 Urs. Min.** S. P.	5	14 55 45.5	0.942	+113 36 33	14.38	2.40
163	α Ceti	2–3	2 56 16.1	3.130	+ 3 38 16	14.32	1.00
164	γ Persei	3	56 28.4	+4.311	+ 53 03 37	+14.38	1.66
165	ρ Persei	4	57 48.5	3.820	+ 38 23 36	14.27	1.28
166	ρ³ *Eridani*	6–5	2 58 37.7	2.946	— 8 03 06	14.26	1.01
167	β Persei	2–3	3 00 41.2	3.881	+ 40 30 42	14.15	1.31
168	ι Persei	4	00 46.3	4.296	+ 49 10 43	14.08	1.53
169	*B. A. C.* 978	6–7	3 02 56.2	+2.569	— 28 16 16	+14.19	1.14
795	***Gr. 2213. S. P.***	7–6	15 03 21.3	—6.701	+ 95 36 15	13.97	10.24
170	δ Arietis	4–5	3 05 03.2	+3.420	+ 19 17 28	13.86	1.06
171	**48 Cephei**	6–7	05 45.7	7.391	+ 77 18 34	13.77	4.55
172	12 Eridani (*a*)	3–4	07 11.2	2.544	— 29 26 29	14.38	1.15
173	ζ Arietis	4–5	08 17.5	+3.439	+ 20 37 03	+13.57	1.15
174	ζ *Eridani*	4–5	10 14.9	2.910	— 9 14 52	13.52	1.02
175	*B. A. C.* 1017	5	3 11 32.5	3.746	+ 33 48 03	13.37	1.20
804	**1 Urs. Min.**, S. P.	5–6	15 13 19.2	0.663	+112 12 59	13.73	2.64
176	κ¹ *Ceti*	5	3 13 19.8	3.141	+ 2 56 50	13.31	1.00
807	**57 Urs. Min.** S. P.	6–7	15 14 36.4	—21.642	+ 92 19 34	+13.21	24.64
177	α Persei	2	3 16 07.0	+4.255	+ 49 27 03	13.12	1.54
178	ο Tauri	4–3	18 37.6	+3.226	+ 8 37 23	12.90	1.01
179	ι Hydri	5	18 50.7	—1.613	— 77 48 29	13.01	4.74
180	2 Camelop.	5–4	3 19 45.7	+4.809	+ 59 32 18	12.93	1.97
815	γ² **Urs. Min.**, S. P.	3	15 20 55.1	—0.137	+107 45 24	+12.81	3.28
181	ξ Tauri	4–3	3 20 56.2	+3.248	+ 9 19 51	12.78	1.02
182	σ Persei	5	22 28.1	4.202	+ 47 35 49	12.72	1.48
183	*f* Tauri	4	24 31.4	3.304	+ 12 32 30	12.59	1.02
184	ε Eridani	3	27 30.7	2.823	— 9 50 53	12.41	1.02
185	τ⁶ *Eridani*	4	28 42.4	+2.645	— 22 01 08	+12.27	1.08
186	***Groom. 642***	6	28 59.0	19.503	+ 86 16 58	12.21	15.42
187	10 *Tauri*	4–5	31 00.3	3.058	+ 0 02 09	11.61	1.00
188	Groom. 716	6	32 11.0	5.151	+ 62 50 34	12.11	2.19
189	δ Persei	3	3 34 44.4	4.248	+ 47 25 07	11.83	1.42

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. C. N. H^{3} $G^{5.4.3.2.1}$.	160	[4 or 5-inch. [—$0^{s}.21$: —$1''.0$, 1868. Binary, 2d ∗ = 6½ mag.:	
$G^{5.4.2}$ W. Rd. R . .	161	[= + $0^{s}.80$: + $1''.3$.	
H^{2} O^{1} M.	162	Foll. ∗ = 6¼ mag.:	
B. H^{4} $G^{5.3}$	790	[o^{1} = θ Erid. 3–4 mag.	
A^{1} E. C. B. N. $H^{4.2}$.	163	Fine orange with blue comp.	
B. $G^{5.3.2.1}$ Rd. R. . .	164		
B. $H^{4.2}$ $G^{5.3.2}$ W. Rd. R.	165		
$G^{3.2}$ W. Rd. R. . .	166	Rd. + R. = 9 Eridani ρ^{2}.	
A. C. B. $H^{4.3.2}$ $G^{5.4.3.2.1}$.	167	Mag. 2.3, to 4.0.	
B. $G^{1.3}$ W. Rd. R. .	168	[Period 287 days.	
W.	169		
G^{5} Rd.	795		
E. C. B. N. $H^{4.3.2.1}$ $G^{5.4}$.	170		
A. B. N. $H^{4.3.2}$ G^{5} . .	171	Groom. 616.	
C. B. $H^{4.3.2}$ $G^{5.1}$ W. .	172	Comp. = 8 mag.: [—$0^{s}.29$: + $3''.2$.	
A. N. H^{3} $G^{5.4.3.2.1}$ W. .	173	[—$18^{s}.5$: —$3'$ $00''.8$, 1885.	
$H^{4.3.2}$ $G^{2.1}$ W. Bk. Rd.	174	B. 456 = 7½ mag.:	
$G^{5.4}$ R.	175		
B. H^{4} $G^{5.4.2}$ . . .	804		
$H^{4.2}$ G^{4}	176		
C. $H^{3.1}$ $G^{5.4.3.2}$ W. Rd.	807		
A. E. C. B. N. H^{4-1} $G^{5.4}$.	177		
E. B. $H^{4.3.2}$ $G^{5.4.3.2.1}$ W.	178		
A. O^{1}	179		
B. $G^{4.3.2.1}$ Rd. R. . .	180		
A. C. B. N. $H^{4.3.2}$ $G^{5.4}$.	815		
C. B. $H^{4.2}$ $G^{5.4.3.2.1}$ W.	181		
B. $G^{4.1}$ Rd. R. . .	182	{ Brad. 480 = 6 mag.: + $1^{s}.6$: + $6'$ $37''$.	
A. B. N. $H^{4.2}$ $G^{5.4.3.2.1}$.	183	Brad. 483 = 6 mag.:	
A. E. C. B. N. $H^{4.3.2}$.	184	[+ $1^{m}.33^{s}.0$: + $2'$ $03''$.	
G^{2} Bk. Rd. R. . .	185		
$H^{3.1}$ $G^{5.4.3.2.1}$ W. Rd. .	186		
H^{2} $G^{4.3.2}$ W. R. . .	187		
B. $H^{4.3.2}$ $G^{5.4.3.2.1}$ W. Rd.	188	Piaz. III, 94.	
A. C. B. N $H^{4.3.2}$ $G^{5.4.2.1}$.	189		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.		Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
				h. m. s.	s.	° ′ ″	″	
829	θ	*Urs. Min., S. P.*	5	15 34 50.9	—1.896	+102 16 06	+11.86	4.71
190	ο	Persei . . .	4	3 37 06.5	+3.747	+ 31 55 22	11.71	1.18
191	ν	Persei . . .	4	37 23.0	4.056	+ 42 12 51	11.69	1.35
192	δ	Eridani . . .	3–4	37 44.4	2.869	— 10 09 12	12.40	1.02
193	17	Tauri . . .	4–5	38 02.8	3.552	+ 23 45 03	11.58	1.09
194	γ	**Camelop.** . .	4–5	38 13.8	+6.226	+ 70 58 34	+11.61	3.07
195	η	Tauri . . .	3	40 38.9	3.556	+ 23 44 55	11.40	1.09
196	τ[6]	Eridani . . .	4	41 54.0	2.579	— 23 35 26	10.84	1.09
197	e	*Tauri* . . .	5	41 57.8	3.282	+ 10 47 18	11.31	1.02
198	27	Tauri . . .	4	42 19.5	3.556	+ 23 43 02	11.30	1.09
199	τ[7]	*Eridani* . .	5	42 43.0	+2.577	— 24 13 53	+11.34	1.10
200		*B.A.C.* 1199(*fol.*)	6	44 21.3	2.214	— 37 58 20	11.21	1.27
201	u[3]	*Tauri* . . .	6	45 52.3	3.193	+ 6 11 19	11.08	1.01
202	ζ	Persei . . .	3	46 54.3	3.759	+ 31 32 28	10.97	1.17
203	9	Camelopardalis.	6–5	3 47 20.2	+5.071	+ 60 46 14	10.97	2.04
844	ζ	**Urs. Min.**, S. P.	4	15 48 11.3	—2.256	+101 51 08	+10.91	4.87
204	γ	Hydri . . .	3	3 49 01.8	—1.005	— 74 35 27	10.97	3.77
205	ε	Persei . . .	3	50 08.1	+4.008	+ 39 40 35	10.76	1.30
206		*Groom. 746* .	5–6	50 50.8	9.740	+ 80 22 43	10.76	5.97
207	ξ	Persei . . .	4	51 30.3	3.878	+ 35 27 33	10.66	1.23
208	γ[1]	Eridani . . .	3	52 39.9	+2.798	— 13 50 11	+10.46	1.02
209	λ	Tauri . . .	Var.	54 18.6	3.318	+ 12 09 52	10.43	1.02
210	ν	Tauri . . .	4	57 02.4	3.186	+ 5 40 09	10.25	1.00
211	A[1]	Tauri (37) . .	5–4	57 53.8	3.539	+ 21 45 59	10.10	1.08
212	λ	*Persei* . . .	4–5	58 01.2	4.447	+ 50 02 17	10.13	1.56
213	ψ	*Tauri* . . .	6–5	3 59 53.9	+3.700	+ 28 41 21	+10.93	1.14
214	c	Persei . . .	4	4 00 18.8	+4.334	+ 42 35 45	9.98	1.48
855		*Rad. 3523. S. P.*	7–6	16 00 24.1	—12.130	+ 94 22 12	10.00	13.13
215		**Groom. 750** .	6–7	4 00 45.8	+17.043	+ 85 15 02	9.99	12.08
216		*B. A. C.* 1273 .	5–6	00 53.0	2.456	— 27 58 01	10.04	1.13
217	ω[1]	*Tauri* . . .	6	02 28.0	+3.487	+ 19 18 14	+ 9.80	1.06
218	p	*Tauri* . . .	6	4 03 49.7	3.644	+ 26 10 47	9.69	1.13
861		**Gr. 2320**, S. P.	6–5	16 06 00.5	0.138	+111 53 12	9.50	2.68
219	ο[1]	Eridani . . .	4–5	4 06 15.0	2.926	— 7 08 18	9.64	1.01
220	μ	*Persei* . . .	4–5	06 27.2	4.381	+ 48 06 57	9.49	1.50

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
H^3 $G^{5.4.3.2.1}$ Rd. R. .	829	Groom. 2262.	
B. $G^{5.4.3.2.1}$ R. W. . .	190		
B. $G^{5.4.3.1}$ Rd. R. . .	191		
C. B. $H^{4.2}$ $G^{5.4.3.2.1}$ R. .	192		
B. N. $G^{5.4.3}$ W. $O^{2.1}$.	193		
A. B. $H^{4.2}$ $G^{5.4.3}$ W. .	194	B = 5 H Camelop.	
A. E. C. B. N. $H^{4.3.2.1}$.	195		
B. G^3 W. Rd. . . .	196		
$G^{5.4.3.2.1}$ W. R. . .	197	[+ 1^s.0 + 4′ 00″.	
B. $G^{5.4.3.1}$ W. R. . .	198	28 Tauri = 5–3 mag.:	
G^1 $H^{4.2}$ Bk. W. . .	199	[—0^s.39:—7″.0: *f* Eridani.	
$H^{4.2}$ M.	200	Pr. ✱ = 6¼ mag.:	
G^4 Rd. R.	201	{ ✱ 10 mag.:—0^s.5,:—11″.7	
A. C. B. N. $H^{4.3.2}$ $G^{5.2.1}$.	202	✱ 12 mag.:—2^s.0,:—79″ ✱ 11 mag.:—0^s.8:—2′ 00″	
B. $H^{4.2}$ G^5 Rd. R. . .	203	and a fifth star — 2^s.1, + 11″.6.	
A. E. C. B. $H^{4.3.2}$ G^{5-1} .	844		
A. E. $O^{2.1}$ M. . . .	204	[var. [+ 0^s.13 : + 8″.3 smaller	
A. B. $H^{4.2}$ G^5 W. . .	205	Comp. = 9 mag.:	
H^3 $G^{5.4}$ W. Rd. R. .	206	Piazzi III. h. 168.	
B. $G^{5.4}$ R. W. . . .	207		
A. E. C. B. N. $H^{4.3}$.	208	[Period 3.95 days.	
C. B. N. $H^{4.2}$ $G^{5.4.3.2.1}$.	209	Mag.: 3–4 to 4–3.	
B. G^3 Rd. R. . . .	210	[+37^s.4 : —4′ 04″.	
A. E. N. $G^{5.4.3.2.1}$ W. .	211	A^2 = mag. 6;	
$H^{4.2}$ $G^{5.3.1}$ Rd. . . .	212		
N. H^2 $G^{5.4}$ W. R. . .	213		
A. B. $H^{4.2}$ G^1 W. Bk. .	214		
G^3 Rd.	855		
C. B. $H^{4.3.1}$ $G^{5.4.3}$ W. .	215		
W. Rd.	216		
N. H^2 $G^{5.4.3}$ W. R. .	217		
N. $H^{4.2}$ $G^{5.4}$ R. . .	218		
A. N. $H^{4.3}$ $G^{5.4.3.2}$ W. .	861		
A. E. B. $H^{4.5.2.1}$ $G^{5.4.3.2}$.	219		
H^2 $G^{3.1}$ W. O^2 Rd. R. .	220		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
221	A *Eridani* . .	5	4 08 55.4	+2.851	− 10 32 25	+ 9.46	1.02
222	o^2 Eridani . . .	5–4	09 58.8	2.762	− 7 49 58	5.80	1.01
223	*B. A. C.* 1313 .	6	11 49.1	5.183	+ 60 27 42	9.24	2.03
224	54 Persei . . .	6	12 56.6	3.883	+ 34 17 16	9.04	1.21
225	γ Tauri . . .	4	4 13 15.0	+3.409	+ 15 20 56	8.98	1.04
865	**19 Urs. Min.** S. P.	6	16 14 07.0	−1.786	+103 50 01	+ 8.95	4.18
226	χ^1 *Tauri* . . .	5	4 15 35.1	+3.644	+ 25 21 25	8.79	1.11
227	δ^1 Tauri . . .	4	16 18.2	3.454	+ 17 16 19	8.74	1.05
228	δ^2 *Tauri* . . .	6	17 27.9	3.453	+ 17 10 35	8.63	1.05
229	δ^3 *Tauri* . . .	5	18 50.2	3.465	+ 17 39 50	8.53	1.05
230	υ^5 *Eridani* . .	4	19 43.1	+2.251	− 34 17 03	+ 8.59	1.21
231	***Groom. 828*** .	6–5	4 20 11.2	+6.866	+ 72 16 46	8.46	3.29
872	η **Urs. Min.**, S.P.	5	16 20 52.6	−1.825	+103 58 48	8.13	4.19
232	ε Tauri . . .	4–3	4 21 54.1	+3.497	+ 18 55 27	8.28	1.06
233	1 Camelop. (foll.)	6	22 55.4	4.726	+ 53 39 35	8.23	1.70
234	80 *Tauri* . . .	6	23 35.2	+3.414	+ 15 23 07	+ 8.15	1.04
235	85 *Tauri* . . .	6	25 17.7	3.421	+ 15 36 13	8.01	1.04
236	*m* Persei . . .	6	25 19.5	+4.208	+ 42 49 01	8.05	1.37
237	δ Mensæ . . .	6	25 46.8	−4.245	− 80 28 55	7.99	4.80
238	ρ *Tauri* . . .	5	4 27 19.3	+3.399	+ 14 36 05	7.85	1.03
880	**A Draco.** S. P. .	5	16 28 12.9	−0.137	+110 59 00	+ 7.80	2.79
239	α Tauri . . .	1	4 29 19.3	+3.437	+ 16 16 37	7.54	1.04
240	υ Eridani . . .	3–4	30 34.3	2.992	− 3 35 19	7.633	1.00
241	υ^4 *Eridani* . .	3–4	31 04.8	2.332	− 30 47 54	7.56	1.17
242	α *Doradûs* . .	3–2	31 30.9	1.294	− 55 16 58	7.58	1.76
243	c^1 *Tauri* . . .	5–4	31 43.9	+3.352	+ 12 16 45	+ 7.52	1.02
244	53 Eridani . . .	4	32 54.9	2.747	− 14 31 47	7.38	1.03
245	**Groom. 848** .	6	33 22.7	+7.975	+ 75 43 49	7.58	4.06
246	τ Tauri . . .	4–5	4 35 20.6	+3.595	+ 22 44 06	7.21	1.08
886	**Gr. 2373**, S. P.	6	16 35 35.2	−2.774	+102 19.43	7.21	4.68
247	α *Cœli* . . .	4–5	4 36 51.5	+1.932	− 42 05 01	+ 7.07	1.35
248	β *Cœli* . . .	5–6	37 59.5	2.160	− 37 22 12	7.23	1.26
249	4 Camelopard. .	6–5	38 25.6	4.980	+ 56 33 03	6.73	1.81
250	***Groom. 856*** .	5–6	38 51.9	10.990	+ 81 00 00	6.95	6.39
251	μ Eridani . . .	4–3	4 39 45.2	2.998	− 3 28 00	6.81	1.00

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
G^{5} W. O^{1} Bk. R. . .	221	[+$5^{s}.14$: −$2''.4$	
C. $H^{4.2}$ $G^{5.4.3.2}$ W. R. .	222	Comp. = 9½ mag. :	
G^{5} W. Rd. R. . . .	223	[or bl. : comp. doub. $2''$.	
B. $G^{5.4}$ R.	224		
A. E. C. B. N. $H^{4.3.2}$.	225		
B. $H^{4.4.3}$ $G^{5.4.1}$ Rd. R. .	865	[+$0^{s}.68$: + $16''.6$	
N. $G^{5.4.3}$ $O^{2.1}$ R. . .	226	N. = $\chi : \chi^{2}$ = 8½ mag. :	
B. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$ W.	227	[G^{5} 1872.	
N. $H^{4.2}$ $G^{5.3.2.1}$ W. O^{1} .	228		
N. H^{2} $G^{5.4.2.1}$ Rd. R. .	229		
$H^{4.3.2}$ $G^{2.1}$ O^{1} . . ,	230	$H^{3.2} = v^{3} : o$ + B. A. C. $= v^{5}$	
$G^{2.1}$ Rd.	231		
A. B. $G^{5.4.3.2.1}$ W. Rd. .	872		
A. E. C. B. N. $H^{3.2}$. G .	232	[−$0^{s}.8$: −$5''$.	
B. $H^{4.2}$ $G^{2.1}$ Bk. Rd. .	233	Prec. ✱ = 8½ mag. :	
		[+ $0^{s}.04$ + $1''.7$: 1843 :	
N. $H^{4.2}$ $G^{2.1}$ Bk. R. .	234	Comp. = 8½ mag.	
N. $H^{4.2}$ $G^{5.2.1}$ W. R. .	235	Comp. not seen [with 3.2-inch 1851.	
A. $G^{5.4.3}$ Rd. R. . .	236	Br. = 616 = 7 mag. :	
A. O^{1} M.	237	[− $3^{s}.3$: − $1'$ $47''$.	
N. $H^{4.2}$ G^{1} Bk. R. .	238		
A. B. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$.	880	[$0^{s}.0$ + $1'$ $48''$:	
A^{1} E. C. B. N. $H^{4.2.1}$.	239	Comp. = 12 mag. : [Dawes 2¾-in., Webb $3\frac{7}{10}$.	
B. $H^{4.2}$ $G^{3.2}$ R. . .	240		
H^{2} $G^{5.4.3.2.1}$ W. . .	241		
O^{1} M.	242		
$G^{4.5}$ R.	243		
C. B. $H^{4.3.2}$ G^{2} Bk. R. .	244		
B. H^{3} $G^{5.4.2}$ Rd. R. .	245	[− $2^{s}.5$: − $51''$.	
A. B. N. $H^{4.2}$ G^{5-1} W.	246	Prec. ✱ = 8 mag. :	
B. $H^{4.3}$ G^{5} Rd. . . .	886		
H^{2} O^{1} M.	247		
H^{2} W. O^{1} M. . . .	248		
B. $H^{4.2}$ $G^{5.2}$ Rd. R. .	249		
H^{3} $G^{5.2.1}$ W. Rd. R. .	250	50 Cephei.	
E. B. $H^{4.3.2}$ $G^{5.3}$ W. .	251		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
252	1 Aurigæ . . .	6	4 42 10.2	+4.030	+ 37 17 03	+ 6.74	1.26
253	α **Camelop.** . .	4	42 37.2	5.922	+ 66 08 44	6.64	2.46
254	π¹ Orionis . . .	4	4 43 36.0	+3.255	+ 6 45 34	6.58	1.01
895	***Gr. 2388. S. P.***	6	16 44 30.1	−1.368	+105 54 16	6.49	3.65
255	i Tauri . . .	5–6	4 44 38.8	+3.505	+ 18 38 35	6.43	1.05
256	π⁴ Orionis . .	4–5	45 04.9	+3.191	+ 5 24 27	+ 6.45	1.00
257	o¹ *Orionis* . .	5–6	46 01.7	3.390	+ 14 03 29	6.31	1.03
258	ω *Eridani* . .	4–5	47 02.8	2.947	− 5 39 08	6.27	1.01
259	π⁵ Orionis . . .	4	48 15.7	3.122	+ 2 15 05	6.18	1.00
260	ι Aurigæ . . .	3	49 30.3	3.900	+ 32 59 02	6.05	1.19
261	k *Tauri* . . .	6–5	51 07.2	+3.667	+ 24 52 17	+ 5.87	1.10
262	***Rad. 1311*** . .	6–7	51 07.8	20.489	+ 85 48 23	5.94	13.68
263	β Camelopard. .	4	53 11.6	5.317	+ 60 16 21	5.79	2.02
264	ε Aurigæ . . .	Var.	53 43.0	4.295	+ 43 39 08	5.87	1.38
265	ζ Aurigæ . . .	4	54 26.4	4.182	+ 40 54 24	5.70	1.32
266	ι Tauri . . .	5–4	4 56 13.3	+3.581	+ 21 25 28	+ 5.46	1.07
906	ε **Urs. Min.**, S. P.	4–5	16 57 47.3	−6.345	+ 97 46 31	5.38	7.39
267	11 Orionis . . .	5	4 57 59.9	+3.424	+ 15 14 34	5.32	1.04
268	η Aurigæ . . .	4.3	4 58 27.1	4.198	+ 41 04 40	5.27	1.33
269	ε Leporis . . .	4–3	5 00 35.5	2.536	− 22 31 36	5.07	1.08
270	β Eridani . . .	3	02 11.8	+2.946	− 5 14 09	+ 4.89	1.01
271	**19 Camelop.** . .	5	03 37.5	9.768	+ 79 05 45	5.03	5.29
272	λ Eridani . . .	4	03 38.7	2.871	− 8 54 10	4.89	1.01
273	μ Aurigæ . . .	6–5	05 33.6	4.099	+ 38 20 48	4.65	1.28
274	α Aurigæ . . .	1	5 08 11.7	4.424	+ 45 52 46	4.06	1.44
914	ζ **Draco.**, S. P. .	3	17 08 27.3	+0.167	+114 08 35	+ 4.41	2.45
275	β Orionis . . .	1	5 09 00.7	2.881	− 8 20 08	4.42	1.01
276	λ Aurigæ . . .	5	11 03.0	4.212	+ 39 59 43	3.56	1.30
277	τ Orionis . . .	4	12 01.4	2.914	− 6 58 11	4.18	1.01
278	o *Columbæ* . .	6–5	13 20.2	2.166	− 35 00 31	3.70	1.21
279	λ *Leporis* . . .	4–5	14 16.7	+2.763	− 13 17 47	+ 3.94	1.02
280	ν *Leporis* . . .	6–5	14 38.9	2.783	− 12 26 03	3.94	1.02
281	o *Orionis* . . .	5	15 53.7	3.065	− 0 29 38	3.83	1.00
282	m *Orionis* . . .	5–6	16 47.4	3.152	+ 3 25 58	3.75	1.00
283	η Orionis (mean).	3–4	5 18 41.7	3.012	− 2 30 29	3.61	1.00

FIEFD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
$G^{5.4}$ W. R. . . .	252		
A. B. N. $H^{4.3.2}$ $G^{5.4.3.2}$.	253	9 Camelop.	
C. $H^{4.2}$ G^{1} W. Bk. . .	254	Bk. + H. = π^3 Orionis.	
Rd.	895		
A. N. $G^{5.4.3.1}$ W. R. .	255		
B. Bk. R.	256		
$H^{4.2}$ $G^{4.2.1}$ Bk. Rd. R. .	257		
H^{2} $G^{3.2}$ W. R. . . .	258		
B. G^{3} R.	259		
A. E. C. B. $H^{4.3.2.1}$ G^{5-1}	260		
N. $G^{5.4.1}$ W. $O^{2.1}$ Bk. .	261		
G^{4} Rd.	262		
C. B. $H^{4.3.2}$ $G^{5.3.2.1}$ W. .	263	10 Camelop.	
B. $H^{4.2}$ $G^{5.4.2.1}$ Rd. .	264	Mag. 3½ to 4½ : per. irr.	
A. B. $H^{4.2}$ $G^{5.2.1}$ Bk. .	265		
B. N. $H^{4.2}$ $G^{5.4.3.2.1}$ W.	266		
A. E. C. B. N. H^{4-1} G^{5}.	906		
A. N. H^{2} $G^{5.4.3.2.1}$ W. .	267		
B. $G^{5.4.3.1}$ Rd. R. . .	268		
E. C. B. $H^{3.2.1}$ $G^{5.4.3.2.1}$	269		
A. B. H^{2} $G^{5.2}$ R. . .	270		
B. H^{4} $G^{5.4.3}$ Rd. R. .	271	Piaz. = IV, 269.	
B. $H^{4.2}$ G^{3} Rd. R. .	272		
B. $H^{4.2}$ $G^{5.4}$ W. Rd. R.	273		
A^{1} E. C. B. N. $H^{4.2.1}$ G^{5}	274		
C. B. $G^{5.4.3.2.1}$ Rd. S^{3} .	914	[—0''.25:—9''.1: G^{5} 1872.	
A^{1} E. C. B. N. $H^{4.2.1}$.	275	Pr. ✱ = 9 mag.:	
C. H^{2} $G^{5.4}$ Rd. R. . .	276	[yel. bl. Burnham, [with 1½-inch.	
A. B. $H^{4.2}$ G^{2} Bk. . .	277		
H^{2} W. O^{1} M. . . .	278		
$G^{3.2.1}$ W. R. . . .	279		
$H^{4.2}$ G^{4} R.	280	[— $13^s.8$: — 2'.	
H^{2} $G^{2.1}$ O^{1} Bk. R. .	281	Br. 750=6 mag.:	
$H^{4.2}$ $G^{4.3.2.1}$ W. O^{1} R. .	282	{ G^{4} 679 = 7½ mag.: { + $0^s.9$: — 29'', 1864.	
B. G^{3} Rd. R. . . .	283	Double; 5 mag. and [6 mag.: 1''.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
284	γ Orionis	2	5 18 57.8	+3.218	+ 6 14 40	+ 3.53	1.01
285	β Tauri	2	19 01.4	3.789	+ 28 30 33	3.39	1.14
286	17 Camelop.	6	19 18.6	5.650	+ 62 58 09	3.55	2.20
287	φ *Aurigæ*	5–6	20 01.6	3.978	+ 34 22 35	3.43	1.21
288	ψ *Orionis*	5	20 48.8	3.145	+ 2 59 42	3.41	1.00
289	β Leporis	3–4	23 19.0	+2.570	− 20 51 07	+ 3.10	1.07
290	**Groom. 966**	6–7	24 21.6	7.999	+ 74 57 54	3.13	3.86
291	**64 Camelop.**	6	25 14.3	18.604	+ 85 08 09	3.03	11.79
292	χ Aurigæ	5	25 14.7	3.905	+ 32 06 31	3.05	1.18
293	δ Orionis	Var.	26 07.9	3.063	− 0 23 07	2.95	1.00
294	α Leporis	3	5 27 39.5	+2.645	− 17 54 20	+ 2.82	1.05
933	***Gr. 2456. S. P.***	6–7	17 28 30.2	−4.623	+ 99 45 49	2.77	5.90
295	φ¹ Orionis	5	5 28 30.4	+3.290	+ 9 24 38	2.75	1.01
296	λ¹ *Orionis*	4–5	28 48.2	3.302	+ 9 51 32	2.70	1.02
297	θ¹ Orionis	5–4	29 37.5	2.943	− 5 27 58	2.69	1.00
298	θ² Orionis	5.4	29 44.1	+2.945	− 5 29 34	+ 2.66	1.01
299	ι¹ Orionis	3	29 48.5	2.934	− 5 59 11	2.62	1.01
300	ε Orionis	2	30 22.7	3.042	− 1 16 35	2.59	1.00
301	ζ Tauri	3–4	5 30 46.4	+3.584	+ 21 04 16	2.51	1.07
939	*f* **Draco.** S. P.	5–6	17 32 25.4	−0.254	+111 47 31	2.28	2.69
302	σ Orionis	4–3	5 32 58.3	+3.009	− 2 40 03	+ 2.38	1.00
303	ζ¹ Orionis	2	34 57.4	3.028	− 2 00 16	2.16	1.00
304	α Columbæ	2	35 29.1	2.173	− 34 08 10	2.10	1.21
305	ο Aurigæ	6–5	5 36 59.5	+4.642	+ 49 46 27	1.98	1.55
944	ω **Draco.** S, P.	5	17 37 37.6	−0.356	+111 11 20	1.62	2.77
306	γ Leporis	4	5 39 40.1	+2.499	− 22 29 12	+ 1.40	1.08
307	***Rad. 1553***	6	40 35.1	6.747	+ 68 26 10	1.70	2.72
308	ζ Leporis	4–3	41 44.7	2.718	− 14 51 57	1.58	1.03
309	*k* Orionis	3–2	42 18.1	2.844	− 9 42 42	1.53	1.02
310	υ Aurigæ	4	5 43 31.0	+4.155	+ 39 06 50	1.49	1.29
949	ψ¹ **Draco.**(pr.)S.P.	4–5	17 43 59.1	−1.080	+107 47 42	+ 1.67	3.27
311	δ Doradûs	4–5	5 44 34.2	+0.105	− 65 46 43	1.33	2.44
312	ξ *Aurigæ*	5	45 12.5	5.019	+ 55 40 40	1.58	1.77
313	δ Leporis	4	46 22.5	2.579	− 20 53 23	0.52	1.07
314	β *Columbæ*	3	46 54.4	2.112	− 35 48 48	1.43	1.23

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
C. B. $G^{5.3.2.1}$ W. R.	284		
A^1 E. C. B. N. H^4	285		
B. $G^{5.1}$ Rd. R.	286		
H^2 $G^{5.3}$ R.	287	[$-0^s. + 2''.2$: yel. bl.	
$H^{4.2}$ G^4 Rd. R.	288	Comp. = 11 mag.:	
B. $H^{3.2}$ $G^{3.2.1}$ W. R.	289	[$-0^s.2 : 0''.0$. Comp. = 10–11 mag.:	
A. B. N. $H^{4.3.2.1}$ $G^{5.4.2.1}$	290		
A. H^3 $G^{5.4.3.2.1}$ W. Rd.	291	Groom. 944 = Am. Eph.	
A. H^2 $G^{5.3.2.1}$ W. O^1	292		
A. E. C. B. $H^{4.3.2.1}$ G^{5_1}	293	Var. 2 to 2.7; per. irr. Comp. = 7 mag.: $0^s.0 + 53''$ Burnham, 1878.	
A. E. C. B. N. $H^{4.3.2.1}$	294		
H^3 Rd. R.	933		
B. G^3 R.	295	[$+0^s.3 : + 3''$ 6 yel. purp.	
H^2 $G^{4.3.2}$ R.	296	$\lambda^2 = 6$–7 mag.:	
B. G^1 Bk. R.	297	1st ∗ $- 0^s.6 + 8''.5$: 2d ∗ $- 0^s.3 : + 18''.7$	
B. W. Bk.	298	2d ∗ $+ 0^s.45 : - 4''$ W.	
B. $G^{3.2}$ R.	299	$\iota^2 = 8\frac{1}{2}$ mag.:	
A. E. C. B. N. $H^{4.3.2.1}$	300	[$+0^s.45 : - 9''$.	
B. N. $G^{5.4}$ W. O. Rd.	301		
B. H^4 $G^{5.3.1}$ W. Rd.	939		
B. $H^{4.3.2}$ G^3 Bk. R.	302	s. ″ 2d ∗ 8 mag. + 0.9 + 1.3 3d ∗ 7 mag. + 3.4 + 20.3 wh. bl. red.	
C. H^2 $G^{5.4.3.2.1}$ R.	303	$\zeta^2 = 5\frac{1}{2}$ mag.:	
A. E. C. N. $H^{3.2}$ $G^{5.4.3.2}$	304	[$+0^s.2 : - 3''$.	
B. $H^{4.3.2}$ $G^{5.4.1}$ Rd. R.	305		
A. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$ W.	944		
B. H^2 $G^{5.4.3.2.1}$ R.	306	[μ and μ^1 : yel. garnet. [$-1^s.2, -1' 34''$, large Brad. 836 = 7 mag.:	
$G^{5.4.3}$ Rd.	307	Lalande 10769.	
B. $H^{4.2}$ G^3 R.	308		
A. E. B. H^3 $G^{5.4.3.2}$ W.	309		
A. B. $H^{4.3.2}$ $G^{5.4}$ Bk.	310		
A. B. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$	949	[$+1^s.74 : + 29''.6$. $\psi^2 = 4$–5 mag.:	
A. O^1 M.	311		
H^2 Bk. Rd. R.	312		
B. $G^{4.3}$ R.	313		
$H^{4.2}$ $G^{5.4.3.2.1}$ O^1 M.	314		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
315	α Orionis . . .	Var.	5 48 56.8	+3.247	+ 7 23 04	+ 0.97	1.01
316	δ Aurigæ . . .	4.5	50 03.5	4.937	+ 54 16 27	0.77	1.73
317	β Aurigæ . . .	2	51 05.6	4.406	+ 44 56 03	0.75	1.41
318	η Leporis . . .	4–3	51 10.0	2.730	— 14 11 23	0.93	1.03
319	θ Aurigæ . . .	3	51 52.7	4.091	+ 37 12 10	0.60	1.25
320	γ *Columbæ* . .	4.5	53 27.7	+2.127	— 35 17 51	+ 0.53	1.23
321	*B. A. C.* 1920 .	6–5	5 53 36.9	+2.855	— 9 34 02	0.49	1.01
960	**35 Draco.**, S. P. .	5	17 55 24.3	—2.695	+103 01 22	0.24	4.38
322	μ *Orionis* . . .	5	5 56 03.4	+3.301	+ 9 38 44	0.28	1.01
323	χ^4 *Orionis* . . .	5	57 05.4	3.562	+ 20 08 22	0.23	1.06
324	1 *Geminorum* .	5–4	57 07.8	+3.647	+ 23 16 06	+ 0.15	1.04
325	*B. A. C.* 1946 .	5–6	58 37.7	2.419	— 26 17 02	0.27	1.12
326	66 Orionis . . .	6	5 58 53.8	3.168	+ 4 09 51	+ 0.12	1.00
327	ν Orionis . . .	5–4	6 01 00.4	3.427	+ 14 46 52	— 0.08	1.03
328	**36 Camelop.** . .	6–5	01 16.7	6.030	+ 65 44 21	0.14	2.43
329	***Gr. 1004*** . .	6–7	01 24.4	+26.817	+ 86 45 45	— 0.20	17.71
330	*B. A. C.* 1974 .	6	03 02.0	2.809	— 11 07 45	0.26	1.02
331	θ *Columbæ* . .	5	03 35.1	2.058	— 37 14 13	0.28	1.26
332	ξ *Orionis* . . .	5–4	05 24.1	3.416	+ 14 14 02	0.51	1.03
333	**22 Camelop.** . .	5–4	06 09.6	6.618	+ 69 21 29	0.66	2.84
334	η Geminorum .	3–4	6 07 56.2	+3.623	+ 22 32 20	— 0.71	1.08
970	δ **Urs. Min.**, S. P.	4–5	18 09 24.9	—19.435	+ 93 23 22	0.85	16.91
335	2 Lyncis . . .	4–5	6 09 28.6	+5.300	+ 59 03 03	0.77	1.94
336	k^2 *Orionis* . . .	5–6	09 59.2	3.370	+ 12 18 12	0.68	1.02
337	*B. A. C.* 2021 .	5–6	11 11.9	4.009	+ 35 15 04	1.07	1.22
338	*k* *Columbæ* . .	4–5	6 12 27.7	+2.140	— 35 06 18	— 1.12	1.22
974	**36 Draco.**, S. P. .	6	18 13 14.0	—0.853	+108 43 25	1.98	2.31
339	7 *Monocerotis* .	6	6 14 10.6	+2.894	— 7 46 32	1.22	1.01
340	ζ *Canis Maj.* . .	3–2	15 54.0	2.304	— 30 00 47	1.37	1.16
341	μ Geminorum. .	3	16 00.2	3.632	+ 22 34 17	1.51	1.08
342	ψ^1 Aurigæ . . .	5–6	16 02.5	+4.627	+ 49 20 51	— 1.39	1.53
343	β Canis Maj. . .	3–2	17 38.2	2.641	— 17 54 00	1.56	1.05
344	8 Monocerotis .	5–4	17 40.5	3.180	+ 4 39 01	1.53	1.00
345	6 *Lyncis* . . .	6	20 47.8	5.225	+ 58 14 42	2.18	1.90
346	α Argûs . . .	1	6 21 24.0	1.330	— 52 37 59	1.86	1.65

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. E. C. B. N. H$^{4.3.2.1}$.	315	Mag. 1 to 1.4 : per. irr.	
B. G$^{5.2.1}$ W. Rd. R. .	316		
A. C. B. H$^{4.3.2}$ G$^{5.4.3.2.1}$	317		
B. G$^{2.1}$ W. Bk. R. .	318		
A. C. B. H$^{4.3.2}$ G$^{5.3.2.1}$.	319		
G$^{2.1}$ H$^{4.3.2}$ O^{1} W. M. .	320	6–5 mag. Melbourne.	
G^{4} R.	321	* 6½ mag. :	
B. H$^{4.3.2}$ G$^{5.4.3.1}$ Rd. R.	960	[$-3^s.8 : +10' 24''$.	
H$^{4.2}$ G^{4} W. R.. . .	322		
N. H^{2} G$^{5.3.1}$ W. R. .	323		
N. H^{3} G$^{5.4.3.1}$ . . .	324		
H$^{4.2}$ W. R. . . .	325		
B. G^{3} Rd. R. . . .	326		
A. E. C. B. N. H$^{4.3.2.1}$.	327		
B. H^{4} R. Rd. . . .	328		
G$^{4.3.2.1}$ W. Rd. . .	329		
Bk. R.	330	Bk. = 4 Monocerotis.	
H$^{4.2}$ O^{1}	331		
H^{2} G$^{5.4}$ R.. . . .	332		
A. B. N. H$^{4.3.2}$ G$^{5.3.1}$.	333	Groom. 1100.	
A. E. C. B. N. H$^{4.3.2}$.	334		
A. E. C. B. H$^{4-1}$ G$^{5.4.3.2}$	970		
B. G$^{3.1}$ Rd. R . . .	335		
H$^{4.2}$ G^{4} R.. . . .	336		
G$^{5.4}$ W. R.. . . .	337	Brad. 918.	
H$^{3.2}$ G$^{3.2.1}$ W. . . .	338		
B. H^{3} G$^{5.4.3.1}$ R. Rd. .	974		
G^{3} R.	339		
G$^{4.3.2}$ W. O^{1} R. . .	340	[$+5^s.3 + 0''.0$.	
A. C. B. N. H$^{3.2.1}$ G$^{5-1}$	341	Comp. = 11 mag. : [(5½-in. object.)	
A. B. H$^{3.2.1}$ Bk. Rd. .	342		
C. B. H$^{4.3.2}$ G$^{5.4.3.2.1}$.	343		
B. G^{4} W. R. . . .	344		
G$^{5.4}$ Rd. R. . . .	345		
A. E. C. N. O^{1} M.. .	346		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
347	υ Geminorum .	5–4	6 22 08.1	+ 3.563	+ 20 17 01	− 1.96	1.07
348	10 Monocerotis .	5	6 22 16.8	+ 2.962	− 4 41 32	1.92	1.00
983	φ **Draco.**, S. P. .	4–5	18 22 24.4	− 0.853	+108 43 25	1.98	3.12
985	χ **Draco.**, S. P. .	4–5	18 23 07.6	− 1.070	+107 19 03	1.64	3.36
349	*B. A. C.* 2109 .	4–5	6 23 54.4	+ 2.222	− 32 30 26	2.01	1.19
350	**23 Camelop.** . .	5–6	26 35.1	+10.415	+ 79 41 06	− 2.98	5.59
351	13 *Monocerotis*. .	5–4	26 41.2	3.246	+ 7 24 58	2.35	1.01
352	8 Lyncis . . .	6	27 10.7	5.495	+ 61 34 50	2.63	2.10
353	*B. A. C.* 2147 .	5–6	28 20.8	2.245	− 31 56 32	2.58	1.18
354	ξ² Canis Maj. . .	5	30 14.2	2.515	− 22 52 28	2.60	1.09
355	51 Aurigæ . . .	6.7	30 41.4	+ 4.161	+ 39 29 27	− 2.76	1.30
356	γ Geminorum. .	2–3	31 04.1	3.467	+ 16 29 43	2.74	1.04
357	ν³ *Canis Maj.* . .	6	32 50.1	2.643	− 18 08 19	2.82	1.05
358	15 Monocerotis .	4	34 38.7	3.305	+ 10 10 04	3.01	1.02
359	55 *Aurigæ* . . .	5	6 34 42.8	4.373	+ 44 40 40	3.06	1.41
993	**Gr. 2655.** S. P.	6	18 35 18.1	− 2.855	+102 32 37	− 3.07	4.61
994	**Gr. 2640.** S. P.	6	18 35 51.5	+ 0.187	+114 36 52	3.15	2.42
360	ε Geminorum. .	3–4	6 36 51.4	3.694	+ 25 14 38	3.21	1.11
361	ψ⁵ Aurigæ (56) .	6–5	38 26.9	4.330	+ 43 41 26	3.21	1.38
362	ξ Geminorum. .	4–3	38 50.1	3.370	+ 13 01 06	3.58	1.02
363	α Canis Maj. . .	1	40 04.8	+ 2.644	− 16 33 33	− 4.70	1.04
364	**43 Camelop.** . .	5	41 18.0	6.503	+ 69 01 12	3.54	2.79
365	18 Monocerotis .	4	41 51.9	3.129	+ 2 32 13	3.64	1.00
366	58 Aurigæ . . .	5	42 38.0	4.247	+ 41 54 55	3.84	1.35
367	**24 Camelop.** . .	5.4	43 16.8	8.841	+ 77 07 16	3.75	4.49
368	θ Geminorum. .	3–4	45 12.5	+ 3.960	+ 34 05 55	− 3.98	1.21
369	**51 Cephei.** . .	5	46 15.6	30.016	+ 87 13 26	4.06	20.65
370	*B. A. C.* 2252 .	5	46 41.3	2.180	− 34 13 54	4.02	1.21
371	15 Lyncis . . .	5	47 19.0	5.214	+ 58 36 34	4.26	1.92
372	ε *Geminorum* .	5	48 09.3	3.385	+ 13 19 23	4.24	1.02
373	θ Canis Maj. . .	4–5	48 50.1	+ 2.787	− 11 53 42	− 4.27	1.02
374	ο¹ *Canis Maj.* . .	5–4	49 21.7	+ 2.490	− 24 02 28	4.28	1.10
375	ζ Mensæ . . .	6–5	6 49 35.8	− 4.893	− 80 41 26	4.23	6.18
1006	**50 Draco.**, S. P. .	5–6	18 50 04.6	− 1.906	+104 42 08	4.42	3.94
376	ι *Canis Maj.* . .	5–4	6 51 00.6	+ 2.674	− 16 54 22	4.42	1.05

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. N. $H^{4.2}$ $G^{5.4.3.2.1}$ W.	347		
B. $G^{5.4}$ R.	348		
B. H^{4} $G^{5.2}$ Rd. R. . .	983		
A. B. $H^{4.3.2}$ $G^{5.4.3}$ .. .	985		
$H^{4.2}$ $G^{5.4.3}$ W. . . .	349	[Piaz. VI, 136. $H^3 = \lambda$ Canis Maj.	
B. $H^{4.3}$ $G^{5.4.3}$ W. Rd. .	350	[Piaz. VI, 75. Groom. 1159.	
$H^{4.2}$ G^{4} R. . . .	351		
B. $G^{5.1}$ Rd. R. . . .	352		
$H^{4.2}$ $G^{3.2}$	353	Piaz. VI, 164.	
B. Bk. R.	354		
B. $G^{5.4}$ W. Bk. R. . .	355		
A. E. C. N. H^{3} G^{5}. .	356		
G^{4} R.	357		
B. G^{3} R.	358		
$H^{4.2}$ G^{1} W. Bk. R. .	359	$H^3 = \psi^4$ Aurigæ.	
B. H^{4} G^{5} W. Rd. . .	993		
B. Rd.	994		
A. B. N. $H^{3.2}$ $G^{5.4}$ W. .	360		
A. B. $G^{5.4}$ W. Rd. R. .	361	Comp. 10 mag.: 10″.	
E. B. H^{2} $G^{5.4.3.1}$ W. .	362		
A. E. C. B. N. $H^{4.2.1}$.	363		
B. G^{1} Bk. Rd. R. . .	364		
B. G^{1} R.	365		
$H^{4.2}$ $G^{3.1}$ Rd. R. . .	366	$H = \psi^7$ Aurigæ.	
B. H^{3} G^{2} W. Rd. . .	367		
A. C. B. $H^{4.2}$ $G^{5.2.1}$. .	368	5 mag., B. A. C.	
A. E. C. B. $H^{4.3.2.1}$ G. .	369		
H^{2} W. O^{1}	370		
B. $H^{4.2}$ $G^{5.4}$ Rd. R. .	371		
$G^{5.3.2}$ Rd. R.	372	Double, 5½—8 mags.: 6″.2.	
E. B. H^{3} $G^{5.4.3.2}$ W. .	373		
$H^{4.2}$ $G^{3.2}$ W. R. . .	374		
A. O^{1} M.	375		
A. $H^{4.3.2}$ $G^{5.4.3}$ W. Rd.	1006		
H^{2} $G^{5.4.3.2}$ R. . . .	376		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
1009	**Rad. 4208**, *S. P.*	6–7	18 52 26.3	−18.550	+ 93 26 19	− 4.55	16.67
377	ε Canis Maj. . .	1–2	6 54 06.4	+ 2.358	− 28 48 59	4.70	1.14
1013	υ **Draco.**, S. P. .	5–6	18 55 48.2	− 0.716	+108 51 24	4.87	3.09
378	Piazzi VI (305).	6–7	6 56 11.9	+ 3.280	+ 29 31 46	5.57	1.15
379	ζ² Geminorum. .	4	57 17.3	3.563	+ 20 44 16	4.98	1.07
380	γ Canis Maj. . .	4–5	6 58 33.4	+ 2.717	− 15 27 51	− 5.08	1.04
381	45 *Geminorum.* .	6	7 01 46.3	3.444	+ 16 06 48	5.45	1.04
382	δ Canis Maj. . .	2	03 42.9	2.438	− 26 12 41	5.49	1.11
383	63 Aurigæ . . .	5	03 44.7	4.137	+ 39 30 25	5.44	1.30
384	22 *Monocerotis.* .	4–5	05 59.5	3.066	− 0 18 12	5.71	1.00
385	**25 Camelop.** . .	5–4	7 06 49.9	+13.030	+ 82 37 46	− 5.78	7.78
386	*B. A. C.* 2373 .	6	08 18.5	+ 3.149	+ 3 18 28	5.88	1.00
387	γ² Volantis . .	5–4	09 43.3	− 0.484	− 70 18 42	5.189	2.97
388	64 Aurigæ . . .	6–5	10 02.3	+ 4.184	+ 41 05 10	5.97	1.33
389	λ Geminorum. .	4–3	7 11 29.1	3.452	+ 16 44 48	6.21	1.04
1026	δ **Draco.**, S. P. .	3	19 12 34.2	+ 0.031	+112 32 28	− 6.31	2.61
390	π *Argûs* . . .	2–3	7 13 04.9	2.119	− 36 53 30	6.25	1.25
391	δ Geminorum. .	3–4	13 15.3	3.588	+ 22 11 35	6.32	1.08
392	19 Lyncis (foll.) .	5–6	13 28.8	4.915	+ 55 29 48	6.33	1.77
393	66 *Aurigæ* . . .	5	7 16 10.6	+ 4.166	+ 40 53 32	6.57	1.33
1030	τ **Draco.**, S. P. .	4–5	19 17 45.6	− 1.114	+106 51 30	− 6.78	3.45
394	ι Geminorum. .	4	7 18 35.1	+ 3.737	+ 28 01 32	6.83	1.13
395	**P. VII, 67** . .	5–6	18 54.5	6.303	+ 68 41 54	6.81	2.75
396	η *Canis Maj.* . .	3–2	19 32.8	2.371	− 29 03 45	6.74	1.14
397	β Canis Min. . .	3	20 54.8	3.256	+ 8 31 12	6.99	1.01
398	ρ Geminorum. .	5	7 21 42.8	+ 3.866	+ 32 00 42	− 6.81	1.18
399	6 *Canis Min.* . .	5	23 23.7	3.344	+ 12 14 37	7.14	1.02
400	*B. A. C.* 2478 .	5	24 38.8	2.317	− 31 13 13	7.29	1.17
401	α² Geminorum. .	2–1	7 27 15.7	3.839	+ 32 08 23	7.54	1.18
1039	**Gr. 2900**, S. P.	6–7	19 28 37.8	− 3.512	+100 37 43	7.56	5.42
402	υ *Geminorum* .	4–5	7 28 50.3	+ 3.705	+ 27 09 00	− 7.70	1.12
403	n¹ *Puppis* . . .	4–5	29 27.1	3.541	− 23 13 28	7.74	1.09
404	25 Monocerotis .	5–6	31 33.5	2.981	− 3 50 19	7.76	1.00
405	ο *Geminorum.* .	5–6	31 39.5	3.930	+ 34 50 46	8.11	1.22
406	24 Lyncis . . .	5	7 33 16.4	5.109	+ 58 58 40	7.98	1.94

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
W. Rd.	1009		
A. E. C. B. N. $H^{4.3.2.1}$.	377		
B. $G^{5.3.2.1}$ W. $O^{2.1}$ M. .	1013		
C. G^{1} R.	378	A = var. : N + C. = ζ. 1st comp. 8–9 mag. $-0^s.8 + 1' 32''$.	
A. C. B. N. $H^{4.3.2}$ . .	379	2d comp. 13 mag. $+4^s.6 + 5''.6$.	
E. C. B. $H^{4.3.2.1}$ $G^{5.4.3.2}$	380		
N. H^{2} $G^{5.3.2}$ R. . .	381		
A. C. B. N. $H^{4.3.2}$ G^{5-1}	382		
A. B. $H^{4.3.2}$ $G^{5.4}$ Rd. .	383		
$H^{4.2}$ G^{3} W. R. . . .	384		
A. $H^{3.1}$ $G^{5.4.3.1}$ W. Rd.	385		
. . . .	386	Piaz. VII, 29.	
A. O^{2} M.	387	Var. Am. Eph. $\gamma^1 = 6\frac{1}{2}$ mag.	
B. $H^{4.2}$ G^{1} Rd. R. . .	388	[$-2^s.3 + 6''.3$.	
B. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$ W.	389		
A^{1} C. B. N. $H^{4.3.2}$ G^{5-1} .	1026		
O^{1} M.	390	[$-0^s.2 : -6''.6$.	
A. E. C. B. N. $H^{4.3.2.1}$ G.	391	Comp. = $9\frac{1}{2}$ mag.	
B. $G^{5.4}$ Rd. R. . . .	392	Pr. $7\frac{1}{2}$ mag. $-1^s.2 : +9''$ fol. 8 mag. $+1^s.2 + 3' 34''$.	
$H^{4.2}$ G. Rd. R. . .	393		
A. B. N. $H^{4.3}$ $G^{5.4.3.2}$ W.	1030		
B. N. $H^{4.2}$ $G^{5.3.2.1}$ W. O^{1}	394		
A. B. N. $H^{4.3}$ $G^{5.4.2.1}$ W.	395	Groom. 1308.	
$H^{4.3.2}$ $G^{5.2.1}$ W. M. O^{1} .	396	m = Piaz. VII 103 = $7\frac{1}{4}$ mag.:	
A. E. C. B. $H^{4.2}$ $G^{5.4.2}$	397	[$-13^s.1 + 56''.3$.	
B. $H^{4.2}$ $G^{5.4.2.1}$ W. Bk.	398		
$H^{4.2}$ G^{4} W. R. . . .	399		
. . . .	400	[$-0^s.42 : -2''.3$ G^5.	
A. E. C. B. N. $H^{4.2.1}$.	401	$a^1 = 3$ mag.:	
B. $H^{4.3}$ G^{5} Rd. . .	1039		
N. $G^{5.4.3.1}$ W. O^{1} Rd. .	402		
G^{3} R.	403	$n^2 = 6$ mag.: $+0^s.6 : +2''$.	
B. G^{4} R.	404		
$H^{4.2}$ $G^{5.4}$ W. R. . .	405		
B. G^{1} Rd. R. . . .	406		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
407	α Canis Min. . .	1	7 33 16.9	+ 3.144	+ 5 31 08	− 8.98	1.01
408	γ *Monocerotis* .	4–5	35 45.2	2.866	− 9 17 01	8.16	1.02
409	κ Geminorum. .	4–3	37 30.3	3.629	+ 24 40 22	8.32	1.10
410	β Geminorum. .	1–2	7 38 16.7	+ 3.680	+ 28 18 11	8.40	1.14
1048	λ **Urs. Min.**, S. P.	6–7	19 38 56.5	−63.646	+ 91 02 38	8.41	54.90
411	π Geminorum. .	6	7 40 05.5	+ 3.879	+ 33 41 49	− 8.48	1.20
412	4 *Puppis* . . .	5	40 39.2	2.764	− 14 17 05	8.54	1.03
413	**B. A. C. 2320**	6–7	41 02.0	70.110	+ 88 58 17	8.54	55.71
414	*o Puppis* . . .	4–5	43 18.4	2.495	− 25 39 07	8.69	1.11
415	ξ Argûs . . .	4–3	44 27.5	2.524	− 24 34 19	8.81	1.10
416	26 Lyncis . . .	6	7 46 20.2	+ 4.390	+ 47 51 41	− 8.98	1.49
417	**Groom. 1374.**	6–5	46 24.5	7.293	+ 74 13 15	9.01	3.68
418	9 Argûs . . .	5	46 26.8	2.778	− 13 35 38	9.35	1.03
419	φ Geminorum. .	5	46 27.5	3.681	+ 27 03 45	9.01	1.12
420	*B. A. C.* 2629 .	5	7 47 58.1	2.237	− 34 25 02	8.78	1.21
1058	ε **Draco., S. P.** .	4	19 48 33.1	− 0.177	+110 01 30	− 9.19	2.92
421	***156 Camelop.*** . .	6–5	7 49 16.5	+15.167	+ 84 23 12	9.22	10.22
422	1 *Cancri* . . .	6–5	50 27.7	3.412	+ 16 05 48	9.34	1.04
423	53 Camelop. . .	6	51 52.8	5.172	+ 60 38 14	9.42	2.04
424	14 *Canis Min.* . .	6	52 23.0	3.118	+ 2 31 36	9.44	1.00
425	χ *Argûs* . . .	4	7 53 51.2	+ 1.530	− 52 40 28	− 9.54	1.65
426	ω^1 Cancri . . .	6	53 58.4	3.638	+ 25 42 24	9.56	1.11
427	6 Cancri . . .	5	56 27.3	3.695	+ 28 06 56	9.81	1.13
428	μ^1 *Cancri* . . .	6	59 29.4	3.562	+ 22 57 46	10.01	1.09
429	ζ *Argûs* . . .	2–3	59 32.6	2.108	− 39 40 46	9.94	1.30
430	27 Lyncis . . .	5–4	7 59 48.1	+ 4.537	+ 51 50 13	−10.00	1.62
431	μ^2 *Cancri* . . .	6–5	8 00 59.8	3.539	+ 21 54 53	10.18	1.08
432	**3 Urs. Maj.** . .	6	01 21.5	6.054	+ 68 48 39	10.13	2.77
433	15 Argûs (ι) . .	3	02 38.8	2.554	− 23 58 25	10.12	1.09
434	ψ^2 *Cancri* . . .	5–6	03 31.5	3.622	+ 25 51 19	10.66	1.11
435	16 *Puppis* . . .	5	8 03 53.7	+ 2.683	− 18 54 33	−10.29	1.06
436	**Groom. 1408.**	5	05 04.1	7.706	+ 76 06 21	10.41	4.16
437	ζ^1 Cancri . . .	5–4	05 37.0	3.447	+ 17 59 35	10.58	1.06
438	γ Argûs . . .	2–3	05 59.0	1.852	− 49 59 52	10.45	1.47
439	20 Puppis . . .	5	8 08 02.9	2.758	− 15 26 35	10.64	1.04

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A^1 E. C. B. N. $H^{4.2}$ $G^{5.4}$	407		
$H^{4.2}$ G^3 R. . . .	408		
B. $G^{5.4.3.2.1}$ W. O^1. Rd.	409		
A^1 E. C. B. N. $H^{4.2.1}$.	410		
A. E. C. B. $H^{4.3.2.1}$ $G^{5.4}$	1048		
B. N. $H^{2.1}$ $G^{5.4}$ W. .	411		
$H^{4.2}$ G^4 W. R. . .	412	[Groom. 1119:	
C. $H^{2.1}$ $G^{5.4.3}$ W. Rd. .	413	{ H^4 = 4 Urs. Min. 6 mag. = G^5 = 755.	
$H^{4.2}$ W. R.	414	[—$15^s.4$: —3′ 16″.	
E. C. $H^{3.2}$ $G^{5.4.3.2.1}$ W.	415	Brad. 1130 = 6½ mag.:	
A. B. G^1 Bk. Rd. R. .	416		
A. B. $H^{4.3.2}$ $G^{5.4.3.2.1}$ W.	417		
C. G^3 W. R. . . .	418	C = 6 mag..	
A. N. $H^{4.2}$ $G^{5.3.2.1}$ W. .	419		
H^1 G^5 W. O^1 . . .	420		
A. B. N. $H^{4.2}$ $G^{5.4.3.1}$.	1058	[—$0^s.02$: + 2″.6: yel. bl. Pr. * = 9.5 mag.:	
$H^{3.1}$ G^1 W. Rd. . .	421	Groom. 1359.	
N. H^2 $G^{5.4.2.1}$ W. R. .	422		
B. $G^{5.4}$ W. Rd. R. .	423		
H^2 G^3 R.	424		
O^1 M.	425		
A. N. H^2 $G^{5.3}$ R. . .	426		
E. C. B. N. $H^{2.1}$ G^{5-1}.	427	H^1 + B = κ Geminorum.	
N. H^2 $G^{5.4.1}$ W. R. .	428		
H^3 O^1 M.	429		
B. $G^{2.1}$ Bk. Rd. R. .	430		
N. H^2 $G^{5.4}$ W. R. . .	431		
A. N. H^4 $G^{5.4.3}$ W. .	432	G^5 + Rd. = 55 Camelop.	
A. E. C. B. N. $H^{4.3.1}$.	433	{ C = ρ Argûs = 3–4 mag.: ι Navis = H^3.	
N. $G^{5.4.3.2}$ W. O^1 R. .	434		
H^2 G^3 O^1 R. . . .	435	[—2^m $45^s.6$: —34″.6	
B. H^4 $G^{5.4}$ Rd. R. . .	436	Gr. 1403 = 5 mag.	
A. N. $H^{4.2}$ $G^{5.4.3.2.1}$ W.	437	ζ^2 (double) = 6 mag.	
C. O^1 M.	438	B. A. C. 2754 = 5 mag.	
B. $H^{4.2}$ G^3 O^1 R. . .	439	[—$2^s.77$ —32″.0 [3d * 8 mag.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
440	β Cancri . . .	4–3	8 10 16.7	+ 3.258	+ 9 32 21	—10.84	1.01
1075	***Gr. 3402 S. P.*** . .	Var.	20 11 50.8	—49.281	+ 91 13 08	10.91	47.08
1077	κ **Ceph. (pr.) S. P.**	4–5	20 12 44.6	— 1.916	+102 38 09	10.98	4.57
441	χ *Cancri* . . .	6–5	8 13 04.7	+ 3.655	+ 27 35 21	11.38	1.13
442	q. *Puppis* . . .	5	14 15.1	2.241	— 36 18 14	11.03	1.24
443	31 Lyncis . . .	5	8 14 57.7	+ 4.131	+ 43 33 21	—11.24	1.43
444	d^1 *Cancri* . . .	6–5	16 46.7	3.442	+ 18 42 02	11.30	1.06
445	w *Puppis* . . .	5	16 51.4	2.365	— 32 41 21	11.37	1.19
446	B. A. C. 2825 .	4–3	19 54.9	3.001	— 3 31 56	11.49	1.00
447	ε *Argûs* . . .	2	20 09.2	1.232	— 59 08 22	11.48	1.95
448	o Urs. Maj. . .	3–4	8 20 42.1	+ 5.035	+ 61 06 03	—11.70	2.07
449	***Groom. 1418*** .	6	21 14.5	16.807	+ 85 27 29	11.59	12.63
450	29 *Cancri* . . .	6	22 12.2	3.353	+ 14 35 26	11.69	1.03
451	*B. A. C.* 2846 .	6–7	23 00.9	+ 2.551	— 25 45 11	11.67	1.12
452	θ Chamæleon. .	5–4	24 04.9	— 1.698	— 77 06 47	11.78	3.48
453	θ *Cancri* . . .	6–5	8 25 02.3	+ 3.428	+ 18 28 56	—11.93	1.05
454	Groom. 1450 .	6–7	25 26.3	3.911	+ 38 24 35	12.09	1.28
455	η Cancri . . .	6	26 03.5	3.479	+ 20 49 51	11.99	1.07
456	**Groom. 1446** .	6	26 43.8	6.814	+ 74 05 17	11.95	3.65
457	*B. A. C.* 2887 .	5–6	8 29 46.7	+ 4.516	+ 53 48 03	12.23	1.69
1090	**Gr. 3241, S. P.**	6–7	20 30 29.8	— 0.217	+107 51 29	—12.23	3.23
458	Groom. 1460 .	6	30 46.0	+ 4.472	+ 53 06 49	12.28	1.66
459	δ Hydræ . . .	4–5	8 31 34.0	3.181	+ 6 06 14	12.30	1.01
460	σ Hydræ . . .	5	8 32 44.9	+ 3.147	+ 3 44 39	12.42	1.00
1092	**73 Draco. S. P.** .	5–6	20 33 00.9	— 0.725	+105 26 23	12.40	3.76
461	6 *Hydræ* . . .	6–5	8 34 34.6	+ 2.843	— 12 04 10	—12.54	1.02
1097	***75 Draco. S. P.*** .	5–6	20 35 24.4	— 3.514	+ 98 58 19	12.57	6.41
1099	***74 Draco. S. P.*** .	6–7	20 36 02.5	— 3.244	+ 99 18 43	12.85	6.18
462	γ Cancri . . .	4–5	8 36 37.8	+ 3.481	+ 21 52 53	12.71	1.08
463	δ Cancri . . .	4	38 08.9	3.417	+ 18 34 34	13.00	1.05
464	***Groom. 1463*** .	6	8 38 34.2	+ 9.196	+ 80 27 26	—12.80	6.03
465	α Mali. . . .	4	38 58.5	2.412	— 32 46 22	12.74	1.19
466	ι Cancri . . .	4	39 44.2	3.644	+ 29 10 47	12.90	1.14
467	ε Hydræ . . .	3–4	40 41.2	3.182	+ 6 50 24	12.99	1.01
468	δ *Argûs* . . .	3–2	8 41 31.8	1.660	— 54 17 16	13.09	1.71

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. E. C. B. $H^{4.3.2}$ $G^{5.4.3.2}$	440		
$G^{5.4.3}$ W. Rd. . . .	1075	Mag. : 5 = G^{5}.	
A. B. N. $H^{4.3.2}$ $G^{5.3.1}$.	1077	Foll. ✻ = 8–5 mag.	
N. H^{2} $G^{5.4.3}$ O^{1} R. .	441	[+ $2^{s}.17$: − $4''.5$.	
H^{2} O^{1} M.	442		
B. $G^{2.1}$ W. Rd. R.. .	443		
N. $G^{5.4.3.2.1}$ W. O^{2} R. .	444		
$H^{4.2}$ G^{3} W. O^{1}. . .	445		
A. B. H^{2} W. R. . .	446	[=30 Monoc. Am. Eph. Brad. 1197	
O^{1} M.	447		
B. $H^{4.3.2}$ $G^{5.4.2.1}$ W. .	448		
H^{3} $G^{5.4.3.2}$ W. Rd. R. .	449		
N. $G^{5.4.2.1}$ W. Rd. R. .	450		
$H^{4.2}$ W. M. . . .	451		
A. O^{1} M.	452		
N. H^{2} $G^{5.4.3.2.1}$ W. O^{1} .	453		
B. G^{5} W. Rd. . . .	454		
A. E. C. B. $H^{4.3.2.1}$ G.	455		
B. H^{4} G^{5} Rd. . . .	456		
$H^{4.2}$ G^{1} Rd. R. . .	457		
A. N. $H^{4.3}$ $G^{5.3}$ W. .	1090		
B. W. Rd. R. . . .	458		
C. $H^{4.2}$ $G^{2.1}$ W. O^{1} .	459		
A. H^{2} G^{3} R. . . .	460		
B. H^{4} $G^{5.4.3.1}$ W. . .	1092		
$H^{4.2}$ $G^{4.2.1}$ R. . . .	461		
$G^{5.4.3.1}$ Bk. Rd. R. . .	1097		
$H^{3.1}$ $G^{5.4.3}$ Rd. R. . .	1099		
A. E. N. $H^{4.2}$ $G^{5.4.3.2.1}$.	462		
E. B. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$	463		
$G^{5.4.3.2}$ Rd.	464		
C. H^{2} $G^{5.4.3.1}$ W. . .	465		
B. $G^{5.3}$ R.	466	[— $0^{s}.2$ — $3''.2$ (1866).	
A. E. C. B. N. $H^{4.3.2.1}$	467	Comp. = 8½ mag. :	
O^{1} M.	468	[Binary 450 years.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
469	ρ *Hydræ* . . .	5	8 42 20.4	+3.182	+ 6 15 43	−13.10	1.01
470	35 *Lyncis* . . .	6–5	44 13.6	4.051	+ 44 09 32	13.14	1.39
471	ρ^2 *Cancri* . . .	6	45 44.8	3.587	+ 28 46 09	13.52	1.14
472	σ^2 Cancri (mean) .	6–5	47 13.5	3.673	+ 31 00 41	13.39	1.17
473	ζ Hydræ . . .	3–4	8 49 19.0	+3.177	+ 6 22 56	13.51	1.01
1114	**76 Draco., S. P.** .	6	20 50 50.7	−4.014	+ 97 53 44	−13.62	7.28
474	ι Urs. Maj. . .	3	8 51 19.8	+4.135	+ 48 29 32	13.89	1.51
475	ρ **Urs. Maj.** . .	5	52 09.8	5.499	+ 68 04 36	13.66	2.68
476	α Cancri . . .	4	8 52 11.8	+3.287	+ 12 18 08	13.73	1.02
1115	**T.Y.C.**1879, S.P. .	6–5	20 52 46.4	−2.535	+ 99 52 47	13.70	5.83
477	10 Urs. Maj. . .	4	8 53 10.2	+3.914	+ 42 14 13	−14.03	1.35
478	***Groom. 1480*** .	6	53 58.1	9.416	+ 81 17 15	13.80	6.60
479	Groom. 1501 .	6	55 34.6	4.440	+ 54 44 10	13.87	1.73
480	κ Urs. Maj. . .	3–4	55 46.0	4.119	+ 47 36 36	14.02	1.48
481	ν *Cancri* . . .	6–5	56 00.8	3.518	+ 24 54 16	13.95	1.10
482	B. A. C. 3097 .	5	8 59 12.9	+3.846	+ 38 54 39	−14.19	1.29
483	σ^2 **Urs. Maj.** . .	5	9 00 15.7	5.361	+ 67 36 01	14.25	2.62
484	κ Cancri . . .	5	01 31.1	3.256	+ 11 07 49	14.28	1.02
485	ξ *Cancri* . . .	5	02 43.8	3.408	+ 22 30 36	14.34	1.08
486	*B. A. C.* 3121 .	5–6	03 00.1	2.638	− 25 23 42	14.37	1.11
487	λ *Argûs* . . .	3	9 03 45.9	+2.202	− 42 58 06	−14.37	1.37
488	*e* *Mali* . . .	6–5	05 04.0	2.538	− 29 53 50	14.50	1.15
489	36 Lyncis . . .	5–6	9 06 16.8	+3.949	+ 43 41 26	14.62	1.38
1126	**77 Draco.** S. P. .	6	21 07 45.7	−1.104	+102 20 25	14.69	4.68
490	θ Hydræ . . .	4	9 08 22.9	+3.126	+ 2 47 55	14.96	1.00
491	38 Lyncis . . .	4	9 11 41.0	+3.750	+ 37 17 20	−14.98	1.26
492	β Argûs . . .	1–2	11 56.1	0.683	− 69 14 36	14.78	2.82
493	83 Cancri . . .	6	12 33.0	3.315	+ 18 11 31	15.08	1.05
494	ι Argûs . . .	2	14 00.5	1.601	− 58 47 34	15.00	1.93
495	α Lyncis . . .	3–4	14 02.8	3.673	+ 34 52 43	15.04	1.22
496	*h* *Mali* . . .	6–5	9 16 24.2	+2.654	− 25 28 37	−15.05	1.11
497	κ *Leonis* . . .	5–4	17 57.4	3.509	+ 26 40 35	15.30	1.12
498	*B. A. C.* 3207 .	5–6	18 13.9	2.606	− 28 20 35	15.25	1.14
499	κ *Argûs* . . .	3–2	18 33.2	1.853	− 54 31 11	15.26	1.64
500	A *Hydræ* . . .	6	9 19 39.0	3.004	− 4 37 10	15.37	1.00

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
H$^{4.2}$ G^{3} R..	469		
H$^{4.2}$ G$^{4.2.1}$ W. Rd. .	470	[large μ and μ^1.	
G^{3} R.	471	ρ^1=6½ mag.:—14^s.1:—5″:	
A. B. H$^{4.2}$ G$^{5.4}$ R. .	472	2d=6–7 mag.+0^s.28—2″.3	
B. H$^{4.2}$ G^{2} Bk. R. .	473	{ G^5: good test elongated with 3$\frac{7}{10}$ ob. 80 power. divid. with 144 power.	
B. H$^{4.2}$ G$^{5.4.3.2.1}$ W. Rd.	1114	[—0^s.3: + 12″.	
A. E. C. B. N. H$^{4.3.2.1}$	474	Comp. = 13 mag.:	
B. G$^{5.4}$ W. Rd. R. .	175		
E. C. B. N. G$^{5.4.3.2.1}$.	476		
A. B. N. H$^{4.3.2.1}$ G$^{5.4.3.1}$	1115	Brad. 2749.	
B. H^{2} G$^{4.3.2.1}$ Rd. R. .	477		
G$^{2.1}$ W. Rd. . . .	478		
B. Rd..	479		
B. H$^{4.2}$ G$^{2.1}$ W. Bk. .	480		
N. G$^{5.3.2}$ O^{1} R. . .	481		
C. H^{2} G$^{5.3}$ Rd. R. .	482	{ σ^1=9.5 mag.+0^s.74—1″ very dif. to separate with 3.7-in. objec.	
A. B. N. H$^{4.3.2}$ G$^{5.3.2.1}$.	483		
A. E. C. N. H$^{4.3.2}$ G$^{5-1}$.	484		
N. G$^{5.3.2.1}$ W. O^{1} R. .	485		
H$^{4.2}$ W. R. . . .	486		
H^{3} O^{1} M.	487		
H$^{4.2}$ G$^{5.4.3.1}$ W. . .	488	H^{2} = e.	
B. G^{1} W. Bk. Rd. R.	489		
B. H^{4} G$^{5.4}$ W. R. . .	1126	Groom. 3417.	
A. B. H$^{4.3.2}$ G^{3} W. .	490		
B. H$^{4.3.2}$ G$^{5.2}$ W. R. .	491	[+2^s.5: — 1″.0 G^5. 2d = 7½ mag.:	
A. C. O$^{2.1}$ M. . . .	492		
E. C. B. N. H$^{4.3.2.1}$.	493		
A. E. C. N. O^{1} M.. .	494		
A. C. B. H$^{4.2}$ G$^{5.4}$ . .	495	B = 40 Lyncis.	
H$^{4.2}$ G$^{3.2.1}$ W. O^{1} M. .	496	[—0^s.1: —2″.7 Burnham.	
G$^{5.3.2}$ R.	997	Comp. = 10½ mag.:	
H^{2} G^{1} W. R. . . .	498		
O^{1} M.	499		
H^{2} G^{4} R.	500		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
501	1 **Draconis** . .	4–5	9 20 36.8	+ 9.063	+ 81 49 59	—15.42	7.04
502	α Hydræ . . .	2	9 21 56.2	+ 2.949	— 8 09 38	15.44	1.01
1141	**B.A.C.**7504S.P.	6	21 22 23.0	—11.044	+ 93 26 27	15.50	16.66
503	h Urs. Maj. . .	3–4	9 22 27.1	+ 4.795	+ 63 33 50	15.46	2.25
504	d **Urs. Maj.** . .	5–4	24 17.7	5.408	+ 70 20 05	15.54	2.97
505	θ Urs. Maj. . .	3	9 25 09.6	+ 4.044	+ 52 12 03	—16.20	1.63
506	ξ *Leonis* . . .	6	9 25 34.8	3.239	+ 11 48 30	15.76	1.02
1144	β² **Cephei**, S. P. .	3	21 27 10.3	0.796	+109 56 39	15.75	2.93
507	10 Leo. Min. . .	5	9 27 10.6	3.694	+ 36 54 26	15.77	1.25
508	33 *Hydræ* . . .	6	28 48.4	2.997	— 5 24 11	16.00	1.00
509	10 *Leonis* . . .	5–6	9 31 08.3	+ 3.170	+ 7 21 03	—15.97	1.01
510	42 *Lyncis* . . .	6	31 10.7	3.786	+ 40 45 19	15.97	1.32
511	**Groom. 1564**.	6	32 23.2	5.235	+ 69 45 36	16.10	2.89
512	***Groom. 1562*** .	6	33 36.3	7.452	+ 79 39 46	16.10	5.57
513	ι *Hydræ* . . .	4–5	33 59.0	3.067	— 0 37 18	16.20	1.00
514	ο Leonis . . .	4–3	9 35 00.7	+ 3.207	+ 10 24 54	—16.22	1.02
515	ζ Chamæleon. .	5	37 14.2	— 1.541	— 80 25 28	16.30	6.01
516	ψ *Leonis* . . .	6	37 28.1	+ 3.274	+ 14 32 49	16.32	1.03
517	ε Leonis . . .	3	9 39 19.4	3.416	+ 24 18 11	16.40	1.10
1156	**11 Cephei, S. P.** .	5	21 40 14.1	0.903	+109 13 05	16.54	3.04
518	υ Urs. Maj. . .	4–3	9 42 48.3	+ 4.324	+ 59 34 42	—16.75	1.97
519	υ *Argûs* . . .	4–3	44 13.6	1.503	— 64 32 19	16.65	2.33
520	φ *Urs. Maj.* . .	5–4	44 16.5	4.125	+ 54 35 47	16.66	1.73
521	6 Sextantis . .	6	45 26.4	3.025	— 3 42 18	16.70	1.00
522	μ Leonis . . .	4	46 13.3	3.423	+ 26 32 53	16.79	1.12
523	*B. A. C.* 3385 .	6	9 47 48.8	+ 2.667	— 26 47 40	—16.71	1.12
524	**Groom. 1586**.	6–7	48 04.7	5.494	+ 73 25 32	16.86	3.50
525	*B. A. C.* 3398 .	6	50 20.1	3.186	+ 9 27 39	16.89	1.01
526	19 Leo. Min. . .	5	9 50 38.2	3.695	+ 41 36 08	16.96	1.34
1166	**79 A Draco. S. P.**	6–7	21 51 26.0	0.731	+106 50 30	17.01	3.45
527	ν *Leonis* . . .	5	9 52 02.3	+ 3.233	+ 12 59 36	—17.04	1.02
528	π Leonis . . .	5	54 08.1	3.175	+ 8 35 44	17.13	1.01
529	*P. IX*, 229 . .	6	56 58.7	4.048	+ 54 26 49	17.27	1.72
530	*B. A. C.* 3428 .	6	56 59.0	2.917	— 10 44 27	17.23	1.02
531	υ² Hydræ . . .	5	9 59 31.4	2.922	— 12 30 25	17.36	1.02

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. B. N. $H^{4.3.2.1}$ $G^{5.4.3.2.1}$	501		
A. E. C. B. N. $H^{4.2.1}$.	502		
C. $G^{5.4}$ W. Rd. . .	1141		
B. $G^{4.3.2.1}$ Rd. R. . .	503		
A. B. N. $H^{4.2}$ $G^{5.4.3.1}$.	504		
A. E. C. B. N. $H^{3.2.1}$.	505		
N. $G^{5.4.3.2.1}$ W. Rd. R.	506		
A. E. C. B. N. $H^{4.3.2.1}$.	1144	β^1 Cephei $=8\frac{1}{2}$ mag.: [$-2^s.5:-4''.5$.	
A. B. H^2 $G^{5.3}$ W. R. .	507	9 Leo. Min. $=-44^s:+4''$.	
H^2 G^3 W. R. . . .	508		
N. $G^{4.3}$ W. R. . . .	509		
$H^{4.2}$ G^4 Rd. R. . .	510		
B. $H^{4.3}$ Rd. . . .	511		
$G^{5.4}$ W. Rd. . . .	512		
$H^{4.2}$ G^3 R.	513		
A. E. C. B. N. $H^{4.3.2}$.	514		
A. O^1 M.	515		
N. $H^{4.2}$ $G^{5.3.1}$ W. O^1 .	516		
A. E. C. B. N. $H^{4.3.2}$.	517		
A. B. N. $H^{4.2}$ $G^{5.4.3.1}$.	1156		
B. $H^{4.3.2}$ $G^{5.3.2.1}$ W. Rd.	518		
O^1 M.	519	Comp. $=8$ mag.: [$+0^s.6-1''.7$ (1870).	
$H^{4.2}$ $G^{3.2.1}$ W. Rd. R. .	520	Double; not separated.	
B. G^4 R.	521		
A. E. C. B. N. $H^{4.3.2}$.	522		
H^2 W. M.	523		
B. $H^{4.3}$ $G^{5.4.2}$ W. Rd. .	524		
$H^{4.2}$ G^4 R. . . .	525		
A. B. $G^{5.2.1}$ W. Rd. R.	526		
A. N. H^4 $G^{5.4.2}$ W. .	1166		
N. H^2 $G^{5.4.3.2.1}$ W. O^1 .	527		
A. E. C. B. N. $H^{4.3.2.1}$.	528		
G^1 Rd. R.	529		
$H^{4.2}$ R.	530		
C. $H^{4.2}$ G^4 R. . . .	531		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
532	η Leonis . . .	3-4	10 01 03.7	+3.279	+ 17 19 23	−17.41	1.05
533	α Leonis . . .	1-2	02 14.8	3.201	+ 12 31 44	17.47	1.02
534	λ Hydræ . . .	4-5	04 58.9	2.924	− 11 47 10	17.69	1.02
535	34 *Leonis* . . .	6	10 05 27.1	3.235	+ 13 55 21	17.63	1.03
1180	**24 Cephei, S. P.** .	5-4	22 07 35.6	1.166	+108 17 57	17.68	3.20
536	*B. A. C.* 3489. .	6	10 08 01.9	+2.745	− 26 27 20	−17.23	1.12
537	**32 Urs. Maj.** . .	6	09 40.3	4.426	+ 65 40 53	17.81	2.43
538	λ Urs. Maj. . .	3-4	10 09.4	3.642	+ 43 29 17	17.86	1.38
539	ζ Leonis . . .	3	10 17.5	3.346	+ 23 59 24	17.79	1.09
540	22 *Sextantis* . .	6	11 55.0	2.981	− 7 29 41	17.88	1.01
541	***B. A. C. 3495*** .	6-5	10 12 46.8	+9.664	+ 84 50 07	−17.95	11.11
542	γ^1 Leonis . . .	2	13 37.9	3.316	+ 20 25 21	18.08	1.07
543	μ Urs. Maj. . .	3	15 28.5	3.596	+ 42 04 38	18.00	1.35
544	**30 Urs. Maj.** . .	5	15 49.6	4.395	+ 66 08 51	18.03	2.47
545	**30 Camelop.** . .	5	16 57.4	7.868	+ 83 08 34	18.07	8.38
546	γ *Antliæ* . . .	6-7	10 18 38.5	+2.754	− 29 03 59	−18.13	1.14
547	μ Hydræ . . .	4	20 31.7	2.898	− 16 15 10	18.30	1.04
548	β Leo. Min. . .	4-5	21 13.9	3.488	+ 37 17 46	18.33	1.26
549	α Antliæ . . .	4-5	10 21 53.6	+2.745	− 30 29 00	18.25	1.17
1195	***B.A.C.7851,S.P.***	5-6	22 22 19.3	−3.939	+ 94 28 17	18.31	12.83
550	36 Urs. Maj. . .	5	10 23 15.7	+3.880	+ 56 34 11	−18.32	1.82
551	29 *Sextantis* . .	5-6	23 38.4	3.052	− 2 09 02	18.31	1.00
552	δ *Antliæ* . . .	5	24 17.9	2.759	− 30 01 08	18.33	1.17
553	**9 Draconis** . .	5-4	25 17.9	5.275	+ 76 18 17	18.38	4.22
554	ρ Leonis . . .	4	26 45.4	3.165	+ 9 53 53	18.43	1.01
555	37 Urs. Maj. . .	5	10 27 44.8	+3.907	+ 57 40 28	−18.41	1.87
556	48 *Leonis* . . .	6-5	10 28 48.0	3.133	+ 7 32 43	18.44	1.01
1203	**226 Cephei, S. P.** .	5-6	22 30 15.1	1.079	+104 21 58	18.53	4.03
557	ϕ^2 *Hydræ* . . .	6	10 30 39.8	2.928	− 15 44 57	18.56	1.04
558	37 *Leo. Min.* . .	5-4	10 32 15.0	3.396	+ 32 34 23	18.60	1.18
1205	**31 Cephei, S. P.** .	5	22 32 55.7	+1.488	+106 57 13	−18.64	3.43
559	ϕ^3 *Hydræ* . . .	5	10 32 58.8	2.919	− 16 16 47	18.59	1.04
560	**35 Urs. Maj.** (H).	5	34 49.3	4.386	+ 69 46 14	18.68	2.89
561	33 Sextantis . .	6-7	35 33.1	3.051	− 1 06 59	18.81	1.00
562	34 *Sextantis* . .	6-7	10 36 41.2	3.100	+ 4 11 01	18.73	1.00

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
B. N. $H^{4.2}$ $G^{5.3.1}$ W. .	532		
A. E. C. B. N. $H^{4.2.1}$.	533	Star 8–5 mag.: [“Dist. attendant.”	
B. $H^{4.3.2}$ G^{3} R. . .	534		
N. $G^{5.3.2}$ R. . . .	535		
B. H^{4} $G^{5.4.2.2}$ W. Rd. .	1180		
H^{2} W. M.	536		
A. N. $H^{4.2}$ $G^{5.4.2.1}$ W. .	537		
A. C. B. $H^{4.3.2}$ $G^{5.3.2.1}$.	538		
B. $G^{5.3}$ R.	539		
$H^{4.2}$ $G^{5.1}$ R. . . .	540		
$G^{5.3.2.1}$ W. Rd. R. . .	541	G^{2} = “double star.” [Br. 1399; Gr. 1620.	
A. E. C. N. $H^{4.3.2.1}$ G. .	542	{R. = 4–9 mag.: S. = 6½ mag. {γ^{2} = 3–4 mag. + $0^{s}.22$, —1″.2	
B. $H^{4.2}$ $G^{5.4.2.1}$ Rd. .	543		
B. $G^{5.4.3}$ W. Rd. R. .	544	Brad. 1429.	
B. $H^{3.1}$ $G^{5.2.1}$ W. R. .	545	Piaz. X, 22. Star precedes [$7^{s}.6$.	
$H^{4.2}$ W.	546		
A. E. B. $H^{3.2}$ $G^{5.4.3.2}$.	547		
A. B. $H^{4.2}$ $G^{5.4.3}$ W. .	548	31 Leo. Min.	
A. C. B. $H^{4.2}$ $G^{5.4.3.1}$.	549		
H^{3} $G^{5.4.3.2}$ W. Rd. R. .	1195		
B. $G^{5.4.3.1}$ W. Rd. . .	550		
G^{2} Bk. R.	551		
H^{2} W.	552		
A. B. N. $H^{4.2}$ $G^{5.4}$.	553	Brad. 1446.	
A. E. C. B. N. $H^{4.3.2.1}$.	554		
B. $G^{5.4.1}$ W. Rd. R. .	555		
N. $H^{4.2}$ $G^{5.4.1}$ W. . .	556		
A. N. $H^{4.3.2}$ $G^{5.4}$ N. .	1203		
$H^{4.2}$ G^{4} R.	557		
$G^{5.3}$ W. R.	558	Var.	
B. H^{4} $G^{5.4.3.1}$ W. Rd. .	1205		
H^{2} $G^{4.3}$ W. R. . .	559		
B. $H^{4.3}$ $G^{5.1}$ W. Rd. .	560	Piaz. X, 126. R = var.	
B. $G^{3.2}$ W. R. . . .	561		
N. $G^{5.4.3.2.1}$ W. O^{2} Rd.	562		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
563	*B. A. C.* 3665 .	6	10 36 47.2	+3.553	+ 46 48 30	−18.82	1.46
564	41 Leo. Min. . .	6–5	37 09.7	3.272	+ 23 47 24	18.73	1.09
565	θ *Argûs* . . .	3–4	38 51.2	2.120	− 63 47 33	18.82	2.25
566	42 Leo. Min. . .	5–4	39 28.1	3.350	+ 31 17 14	18.87	1.17
567	37 Sextantis . .	6	40 06.5	3.129	+ 6 58 44	18.89	1.01
568	η Argûs . . .	Var.	10 40 36.1	+2.313	− 59 04 48	−18.87	1.94
569	b^1 *Hydræ* . . .	6	41 14.0	2.935	− 16 41 26	18.91	1.04
570	μ *Argûs* . . .	3–4	41 49.5	2.564	− 48 48 47	18.98	1.51
571	*l* Leonis . . .	5	43 12.8	3.159	+ 11 09 12	18.97	1.02
572	υ Hydræ . . .	4–3	43 57.0	2.950	− 15 35 34	18.96	1.04
573	41 *Sextantis* . .	5–6	10 44 32.0	+3.011	− 8 17 19	−19.00	1.01
574	δ^2 Chamæleon. .	5	10 44 41.3	0.615	− 79 56 02	19.00	5.72
1218	ι **Cephei**, S. P. .	4–3	22 45 35.2	2.121	+114 24 16	18.87	2.42
575	46 Leo. Min. . .	4	10 46 52.7	3.371	+ 34 50 05	19.28	1.22
576	ω *Urs. Maj.* . .	5	10 47 21.4	+3.476	+ 43 48 06	19.09	1.38
1220	***34 Cephei, S. P.*** .	5	22 47 53.5	−0.083	+ 97 27 23	−19.12	7.71
577	54 *Leonis* . . .	4–5	10 49 23.1	+3.260	+ 25 21 46	19.10	1.11
578	**Groom. 1706.**	6–5	50 43.3	4.992	+ 78 23 09	19.19	4.97
579	*B. A. C.* 3755 .	5–6	51 21.6	2.781	− 36 31 13	19.31	1.24
580	47 *Urs. Maj.* . .	6–5	53 01.7	3.380	+ 41 02 39	19.11	1.33
581	α *Crateris*. . .	4	10 54 10.3	+2.919	− 17 41 11	−19.09	1.05
582	*d* Leonis . . .	5	54 37.3	3.100	+ 4 14 04	19.27	1.00
583	β Urs. Maj. . .	2–3	10 54 53.9	+3.662	+ 56 59 54	19.22	1.84
1128	***36 Cephei, S. P.*** .	5–4	22 55 17.1	−0.243	+ 96 16 10	19.25	9.16
584	α Urs. Maj. . .	2	10 56 37.4	+3.751	+ 62 22 18	19.36	2.16
585	χ Leonis . . .	5	10 59 05.1	+3.098	+ 7 57 27	−19.39	1.01
586	η Octantis . .	6	11 00 04.6	−0.272	− 83 58 32	19.41	9.53
587	p^3 Leonis . . .	6–5	01 02.2	+3.061	+ 2 34 46	19.48	1.00
588	ψ Urs. Maj. . .	3–4	11 03 11.8	3.395	+ 45 07 19	19.52	1.42
1234	π **Cephei**, S. P. .	5	23 04 14.5	1.888	+105 14 03	19.41	3.81
589	β Crateris . . .	4	11 06 00.2	+2.946	− 22 11 54	−19.62	1.08
590	***Groom. 1747*** .	7–6	07 39.9	4.623	+ 78 56 08	19.54	5.21
591	δ Leonis . . .	2–3	07 59.5	3.199	+ 21 09 13	19.68	1.07
592	θ Leonis . . .	3–4	08 12.3	3.156	+ 16 03 29	19.61	1.04
593	*n* *Leonis* . . .	6–5	11 09 50.9	3.144	+ 13 56 03	19.60	1.03

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
$H^{4.3}$ G^4 Rd. R. . .	563		
A. B. W. R. . . .	564		
O^1 M.	565		
B. $H^{4.3}$ $G^{5.4.3}$ W. . .	566		
C. N. G^3 W. R. . .	567		
A. E. C. N. O^6 M. .	568	Mag. 1 to 6: per. irr.	
$H^{4.3}$ G^4 R. . . .	569		
O^1 M.	570		
A. E. C. B. N. $H^{4.3.2.1}$.	571		
C. B. Bk. Rd. R. . .	572		
H^3 G^4 R.	573		
A. O^1 M.	574	[$-31^s.9: +4' 17''$. $\delta^1 = 6$ mag.:	
A. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$.	1218		
A. B. $G^{5.4.1}$ W. R. . .	575		
$H^{4.3}$ $G^{5.4.3.1}$ O^2 Rd. R.	576		
$H^{3.1}$ $G^{5.4.1}$ W. Rd. R. .	1220		
$H^{4.3}$ $G^{5.3}$ W. R. . .	577	Foll. ✱ = 8 mag.: [$+0^s.5: -2''.7$.	
A. B. H^4 G^5 W. Rd. .	578		
$H^{4.3}$ $G^{4.3}$ W. O^1 . .	579		
$G^{5.4.3}$ Rd. R. . . .	580		
$H^{4.3}$ G^3 Bk. Rd. R. .	581	R. Crat. = 8 mag., scarlet, almost blood color,	
E. N. $G^{5.4.3.2.1}$ W. $O^{2.1}$.	582		
C. B. H^3 $G^{5.2.1}$ W. Rd.	583		
N. H^3 $G^{5.4}$ W. Rd. .	1228	Groom. 3970.	
A. E. C. B. $H^{4.3.2.1}$ G^{5-1}.	584		
E. C. B. N. $H^{4.3.2.1}$.	585		
A. O^1 M.	586		
A. N. $H^{4.3}$ $G^{4.3}$ W. .	587	$H^3 = p^4$ Leonis.	
A. C. B. $H^{4.3.2}$ $G^{5.4.2.1}$.	588		
B. H^4 $G^{5.4.3.1}$ W. Rd. .	1234		
C. B. $H^{4.3}$ G^3 Bk. . .	589		
Rd.	590		
A. E. C. B. N. $H^{4.3.2.1}$.	591		
B. $G^{5.3.2}$ R. . . .	592		
$H^{4.3}$ $G^{5.3.2.1}$ O^1 Rd. R.	593	$H^2 = n$.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
594	Groom. 1757	6	11 10 12.8	+3.409	+ 50 06 14	−19.59	1.56
595	ξ[1] Urs. Maj.	4–3	12 02.6	3.212	+ 32 10 34	20.21	1.18
596	ν Urs. Maj.	3–4	12 16.1	3.259	+ 33 43 17	19.57	1.20
597	δ Crateris	3–4	11 13 35.5	2.996	− 14 09 23	19.46	1.03
1241	ο **Cephei**, S.P.	6–5	23 13 54.4	2.442	+112 31 03	19.67	2.61
598	σ Leonis	4	11 15 12.4	+3.096	+ 6 39 34	−19.68	1.01
599	**Groom. 1771**	6	16 00.7	3.603	+ 64 57 35	19.66	2.36
600	λ *Crateris*	6–5	17 39.8	2.969	− 18 08 53	19.76	1.05
601	ι Leonis	4–3	17 55.8	3.130	+ 11 09 45	19.80	1.02
602	γ Crateris	4	19 08.3	2.991	− 17 03 08	19.73	1.05
603	*B. A. C.* 3885	5	11 19 27.6	+3.435	+ 56 28 51	−19.68	1.81
604	83 Leonis	7	20 56.0	3.036	+ 3 38 24	19.54	1.00
605	τ Leonis	5	22 01.4	3.086	+ 3 29 23	19.75	1.00
606	***202 Camelop.***	6	23 42.4	4.480	+ 81 45 36	19.78	6.98
607	58 Urs. Maj.	6	24 16.6	3.266	+ 43 48 16	19.74	1.39
608	*e Leonis*	5–4	11 24 26.3	+3.065	− 2 22 09	−19.83	1.00
609	λ **Draconis**	3–4	24 33.9	3.626	+ 69 57 56	19.84	2.92
610	ξ Hydræ	4	11 27 20.8	+2.940	− 31 13 18	19.88	1.17
1251	**39 Cephei**, S.P.	6	23 27 50.2	−0.059	+ 93 19 37	19.87	17.23
611	*B. A. C.* 3934	6	11 28 54.5	+2.917	− 32 13 23	19.10	1.18
612	υ Leonis	5–4	11 31 03.6	+3.071	− 0 11 20	−19.86	1.00
613	ι *Crateris*	6–5	11 32 49.7	3.047	− 12 34 09	19.81	1.02
1258	γ **Cephei**, S.P.	3–4	23 34 37.9	2.411	+103 00 34	20.07	4.40
614	62 *Urs. Maj.*	6	11 35 35.2	3.140	+ 32 22 57	19.91	1.18
615	**3 Draconis**	5–6	36 03.1	3.402	+ 67 22 53	19.91	2.60
616	*B. A. C.* 3973	6–7	11 37 31.7	+3.193	+ 42 21 39	−19.97	1.35
617	ν *Virginis*	4–5	39 56.9	3.085	+ 7 10 25	20.19	1.01
618	χ Urs. Maj.	4	39 58.5	3.192	+ 48 25 00	19.98	1.51
619	A[1] *Virginis*	6–5	11 42 00.4	3.084	+ 8 53 04	20.06	1.01
1266	**41 Cephei**, S.P.	6	23 42 24.9	2.824	+112 49 56	19.98	2.58
620	β Leonis	2	11 43 11.6	+3.064	+ 15 12 53	−20.12	1.04
621	β Virginis	3–4	44 42.3	3.125	+ 2 24 45	20.29	1.00
622	***Groom. 1828***	7	45 08.4	3.303	+ 69 28 29	20.01	2.85
623	Groom. 1830	6–7	46 20.9	3.481	+ 38 32 38	25.72	1.28
624	γ Urs. Maj.	2–3	11 47 46.8	3.184	+ 54 20 03	20.03	1.72

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
B. G^4 W. Rd. R. . .	594	[$+0^s.20 : +1''.2$ G^5.	
C. B. $H^{4.2}$ $G^{5.3.2}$ W. .	595	$\xi^2 = 4–3$ mag.:	
A. B. $G^{5.2}$ W. R. . .	596	$G^2 = 5$ and 5–6 mags.: [Period 61 years.	
A. E. C. B. N. $H^{4.3.2.1}$ G	597		
A. N. $G^{5.4.3.2.1}$ $H^{4.3}$ W.	1241		
B. N. $H^{4.2}$ $G^{5.4.3.2.1}$ W.	598		
B. H^4 $G^{5.4}$ W. Rd. . .	599		
$H^{4.2}$ G^4 R.	600	[$+0^s.2 : +0''.8$ (1870) yl. bl.	
B. N. $G^{5.3.2.1}$ W. O^1 Rd.	601	Comp. = 7½ mag.:	
B. $H^{4.2}$ $G^{4.2}$ R. . .	602		
H^2 G^3 Rd. R. . . .	603	Piaz. XI, 59. [—25''.6.	
C. N. $G^{3.2.1}$ W. R. . .	604	Foll. ✱ 7–8 mag. $+1^s.1$	
A. E. $H^{4.3.2}$ N. $G^{5.4.3.2.1}$	605	Foll. ✱ 8 mag. $+1^s.0$.	
$H^{2.1}$ G^5 W. Rd. . .	606	Groom. 1782 [—1' 32''.8.	
B. G^3 W. Rd. R. . .	607		
N. H^2 $G^{4.2.1}$ W. O^1 .	608	$H^2 = \varepsilon$: = 87 Leonis.	
A. E. C. B. N. $H^{4.2}$.	609		
A. C. B. $H^{4.2}$ $G^{5.3.2}$.	610		
C. $H^{2.1}$ $G^{5.4.2.1}$ Rd. R. .	1251	C = 8213 B. A. C.	
$H^{4.2}$ $G^{5.3.2}$	611	= 20 Crat.: large μ and μ^1. ✱ = 20 Crat., &., &c.	
A. E. C. B. N. $H^{4.3.2.1}$.	612		
H^2 G^4 W. R. . . .	613		
A. E. C. B. N. $H^{4.3.2}$ G .	1258		
H^2 G^4 R.	614		
B. H^4 $G^{5.4.3}$ W. Rd. .	615		
$H^{4.2}$ $G^{5.4}$ Rd. . . .	616		
N. $G^{5.4.3.2.1}$ W. O^1 R. .	617		
A. B. $H^{4.3.2}$ $G^{5.2.1}$ W. .	618		
H^2 $G^{5.3.2}$ W. R. . .	619		
B. H^4 $G^{5.4.3}$ W. Rd. .	1266		
A^1 E. C. B. N. $H^{4.2.1}$.	620	[$1^s.4 + 1'$ 34'' Burn. 1878. Comp. = 13 mag.: Wb. = 8 mag.	
C. B. N. $H^{4.2.1}$ $G^{5.4.3.2.1}$	621		
Rd.	622		
C. $G^{5.4.3.2.1}$ Rd. R. . .	623	Remarkably large μ and μ^1.	
A. E. C. B. N. $H^{4.3.2.1}$ G.	624		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
1272	**Gr. 4163**, S. P.	7–6	23 49 14.9	+2.861	+106 13 47	—20.02	3.58
625	*o Leonis* . . .	6	11 49 45.6	3.089	+ 16 17 13	19.97	1.04
626	*B. A. C.* 4037 .	6	51 12.2	2.983	— 32 41 16	21.77	1.19
627	*b Virginis* . .	6–5	11 54 03.5	3.074	+ 4 17 44	20.07	1.00
1275	***309 Cephei**, S. P.* .	6–7	23 54 06.7	2.614	+ 93 56 02	20.03	14.58
628	π Virginis . .	4–5	11 54 58.8	+3.074	+ 7 15 22	—20.02	1.01
629	67 *Urs. Maj.* . .	5–6	56 16.2	3.064	+ 43 40 38	20.01	1.38
630	***B. A. C. 4070*** .	6–7	58 56.8	3.081	+ 86 13 27	20.06	15.19
631	*o* Virginis . .	4	59 21.1	3.058	+ 9 22 18	20.02	1.01
632	**Groom. 1852**.	6	11 59 23.5	3.136	+ 77 32 56	20.17	4.64
633	*α Corvi* . . .	4–5	12 02 29.0	+3.083	— 24 05 14	—20.10	1.10
634	ε Corvi . . .	3	04 12.7	3.077	— 21 58 48	20.04	1.08
635	5 *Comæ* . . .	6	06 18.4	3.060	+ 21 10 57	20.03	1.07
636	**4 Draconis** . .	5–4	06 48.3	2.891	+ 78 15 19	20.02	4.91
637	1 *Can. Ven.* . .	6	09 01.3	3.005	+ 54 04 28	20.07	1.70
638	*δ Crucis* . . .	3–4	12 09 02.7	+3.150	— 58 06 34	—20.08	1.89
639	δ Urs. Maj. . .	3–4	09 44.0	3.000	+ 57 40 16	20.09	1.87
640	γ Corvi . . .	2–3	12 09 53.6	3.079	— 16 54 12	20.02	1.05
8	**Gr. 29**, S. P. .	6–7	0 09 56.5	3.300	+103 39 48	20.01	4.23
641	2 Can. Ven. . .	5–6	12 10 21.7	3.024	+ 41 18 01	20.07	1.33
642	*B. A. C.* 4128 .	5–6	12 10 43.4	+3.042	+ 33 42 14	—20.03	1.20
643	β Chamæleon. .	5	11 36.2	3.365	— 78 40 24	19.98	5.09
644	**5 Urs. Min.** . .	6	13 29.4	1.831	+ 87 04 30	20.02	19.60
645	η Virginis. . .	3–4	14 01.4	3.069	— 0 01 40	20.04	1.00
646	**6 Urs. Min.** . .	6	14 18.8	0.081	+ 88 20 15	19.95	34.47
647	12 *Comæ* . . .	5	12 16 43.5	+3.023	+ 26 29 04	—20.00	1.12
648	13 *Comæ* . . .	5	12 18 32.5	3.017	+ 26 44 10	20.00	1.12
17	***B. A. C. 86**, S. P.*	6	0 19 46.4	3.702	+100 35 05	19.95	5.44
649	6 Can. Ven. . .	5–6	12 20 11.0	2.969	+ 39 39 24	20.00	1.30
650	$α^1$ Crucis . . .	1	20 11.7	3.269	— 62 27 42	20.02	2.16
651	γ *Comæ* . . .	4–5	12 21 12.3	+2.997	+ 28 54 28	—20.06	1.14
652	$δ^2$ Corvi . . .	2–3	23 55.0	3.105	— 15 52 31	20.10	1.04
653	20 Comæ . . .	6	23 56.6	3.021	+ 21 31 59	19.96	1.08
654	74 Urs. Maj. . .	6	24 35.0	2.828	+ 59 02 19	19.84	1.94
655	γ *Crucis* . . .	2	12 24 47.5	3.290	— 56 28 07	20.24	1.81

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. N. $H^{4.3.2}$ $G^{5.4.3}$ . .	1272		
H^{2} $G^{5.4}$ R.. . . .	625		
H^{2} W.	626	Large μ and μ^{1}.	
N. $H^{4.3.2}$ $G^{5.4.3.2.1}$ O^{1} .	627		
H^{2} $G^{3.2}$ Rd. R. . .	1275		
A. E. C. N. H^{3} $G^{5.4.3.2.1}$	628		
$H^{4.2}$ $G^{3.1}$ W. Rd. . .	629		
H^{3} $G^{5.4.3.2}$ W. Rd. R. .	630	Groom. 1850.	
A. C. B. N. $H^{4.3.2}$ G^{5} .	631		
B. H^{4} Rd.	632		
N. $H^{4.2}$ G^{3} W. O^{1} R. .	633		
A. E. C. B. $H^{4.3.2.1}$ $G^{5.4.2}$	634		
G^{4} R.	635		
A. B. N. $H^{4.3.2}$ $G^{5.4.3.1}$.	636		
H^{2} G^{5} Bk. Rd. R. S. .	637		
O^{1} M. Gi.	638		
B. $G^{5.1}$ W. Rd. R. S. .	639		
A. B. N. $H^{4.3.2}$ $G^{4.2}$ W.	640		
B. H^{4} $G^{5.4.3}$ W. Rd. R.	8		
A. B. H^{3} $G^{3.2.1}$ Rd. R.	641	[—$0^{s}.8$: — $3''.5$. Comp. = 9 mag.:	
H^{2} $G^{4.3}$ W. R. $S^{2.1}$.	642		
A. E. N. O^{1} M. S. .	643		
$H^{3.1}$ $G^{2.1}$ W. Bk. Rd. .	644	Brad. 1656.	
A. E. C. B. N. $H^{4.3.2.1}$.	645		
A. C. $H^{3.1}$ $G^{5.4.3.2.1}$ W.	646	C = B. A. C. 4165.	
$H^{4.3.2}$ $G^{5.3}$ W. R. S^{2} .	647	[+$1^{s}.1$: — $64''$, yl. rd. Comp. = 8 mag.:	
$H^{4.3.2}$ G^{3} R. S^{2} . .	648		
$G^{5.4.3.1}$ R.	17		
B. $G^{2.1}$ Rd. R.. . .	649		
A. E. C. N. O^{1} M. Gi..	650	a^{2} = 2.5 mag. + $0^{s}.77$, — $2''.6$ Melb. a^{2} = — $0^{s}.6$ Comp. = 6 mag. — $5^{s}.0$ — $1'$ $24''$.	
$H^{4.3.2}$ $G^{5.4.3}$ R. S^{2} . .	651		
A. E. C. B. $H^{4.3.2}$ $G^{5.4.3.2}$	652	[— $20''.3$ G^{5} : yel. purp. δ^{1} = 9 mag.: + $1^{s}.00$:	
B. G^{4} W. R. . . .	653		
B. G^{4} Rd. R. . . .	654	[+ $9^{s}.8$: + $1'$ $34''$. Comp. = 5 mag.:	
M.	655	(Very remark. color, Wb).	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
656	η *Corvi* . . .	5–4	12 26 08.6	+ 3.083	— 15 33 32	—19.97	1.04
657	β Can. Ven. . .	4–5	28 16.8	2.860	+ 41 58 56	19.62	1.35
658	β Corvi . . .	2–3	28 20.8	3.141	— 22 45 38	19.97	1.08
659	κ **Draconis** . .	3–4	28 34.3	2.594	+ 70 25 20	19.89	2.98
660	23 Comæ . . .	5	29 07.6	3.013	+ 23 15 45	19.90	1.09
661	24 Comæ (foll.) .	5	12 29 21.7	+ 3.013	+ 19 00 37	—19.86	1.06
662	*f* Virginis . .	6	12 30 51.9	3.086	— 5 11 53	19.91	1.00
28	***Gr. 100. S. P.*** .	6	0 31 08.4	4.286	+ 98 08 35	19.85	6.58
663	χ *Virginis* . .	5	12 33 18.6	3.092	— 7 21 46	19.89	1.01
664	γ *Centauri* . .	3–2	35 10.7	3.280	— 48 19 41	19.85	1.50
665	γ¹ Virginis. . .	3–2	12 35 50.0	+ 3.038	— 0 49 07	—19.81	1.00
666	76 Urs. Maj. . .	6	36 32.3	2.644	+ 63 20 40	19.82	2.23
667	*B. A. C.* 4277 .	6	12 37 43.6	3.076	— 0 56 37	19.78	1.00
35	**21 Cassiop.**, S. P.	6	0 38 03.9	3.850	+105 38 27	19.76	3.71
668	*B. A. C.* 4287 .	5–6	12 39 43.4	3.832	+ 46 04 10	19.73	1.44
669	β Crucis . . .	2	12 41 00.8	+ 3.460	— 59 03 35	—19.75	1.95
670	35 *Virginis* . .	6	42 00.1	3.054	+ 4 12 03	19.73	1.00
671	30 *Comæ* . . .	6	43 41.2	2.928	+ 28 10 44	19.66	1.13
672	31 Comæ . . .	5–6	46 06.0	2.939	+ 28 10 00	19.65	1.13
673	**32 Camelop. foll.**	5–4	48 17.5	0.383	+ 84 02 17	19.60	9.63
674	ψ *Virginis* . .	5	12 48 22.2	+ 3.107	— 8 54 51	—19.64	1.01
675	ε Urs. Maj. . .	2	48 58.0	2.658	+ 56 35 02	19.66	1.82
676	δ Virginis . .	3	49 48.7	3.022	+ 4 01 21	19.67	1.00
677	12 Can. Ven. (α) fol.	3	50 38.9	2.816	+ 38 56 23	19.52	1.29
678	**8 Draconis** . .	5	12 50 53.8	2.413	+ 66 03 45	19.61	2.46
49	***B. A. C. 240, S. P.***	6–7	0 51 57.2	+13.987	+ 91 35 37	—19.48	35.96
51	**43 Cephei**, S. P. .	4–5	0 53 11.5	7.171	+ 94 21 37	19.52	13.15
679	36 *Comæ* . . .	5–4	12 53 14.3	2.972	+ 18 01 47	19.48	1.05
680	δ Muscæ . . .	4	54 22.5	4.023	— 70 55 41	19.48	3.06
681	ε Virginis . .	3–2	56 27.1	2.988	+ 11 34 39	19.42	1.02
682	48 *Virginis* . .	6	12 57 58.9	+ 3.086	— 3 02 39	—19.45	1.00
683	14 *Can. Ven.* . .	5	13 00 21.8	2.816	+ 36 24 51	19.34	1.24
56	**44 Cephei**, S. P. .	6–5	1 02 22.4	4.955	+100 56 20	19.30	5.30
684	ψ *Hydræ* . . .	5	13 02 51.7	3.227	— 22 30 10	19.37	1.08
685	θ Virginis. . .	4–5	13 03 59.7	3.101	— 4 55 29	19.32	1.00

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
H$^{4.3.2}$ G^{3} Rd. R. . .	656		
A. B. H^{3} G$^{5.4.3}$ Rd. R.	657	B = 8 Can. Ven.	
A. E. C. B. N. H$^{4.3.2.1}$.	658		
A. B. N. H$^{4.3.2}$ G$^{5.4.3.2.1}$	659		
C. G$^{5.4.3}$ R. S^{3}. . .	660		
B. H^{3} G^{4} W. R. . .	661	[$-1^{s}.4 : +0''.6$. W = pr. star 6–7 mag.:	
C. N. H$^{4.3}$ G$^{5.4.3}$ W. .	662		
H. G^{5} W. Rd. R. . .	28		
N. H$^{4.3}$ G$^{4.3}$ W. O^{1} .	663		
M.	664	[$-0^{s}.1 + 0''.7$. Star 4½ mag.: (Rapidly moving binary.)	
A. E. C. B. H$^{4.3.2.1}$ G$^{5-1}$	665	γ^{2} = 3–2 mag.: [$+1^{s}.70 - 4''.9$ G^{5}.	
B. G$^{5.4}$ Rd. R. . .	666		
G$^{5.3}$ W. O^{1} R. . . .	667		
A. B. N. H$^{4.2.1}$ G$^{5.4}$ W.	35		
H$^{4.3.2}$ G^{1} Rd. R. S$^{2.1}$.	668		
C. O^{1} M.	669		
H$^{4.3}$ G$^{5.4.3.2}$ W. O^{2} R. .	670		
H$^{3.2}$ G$^{5.4.3.2.1}$ R. S^{3}. .	671		
A. H. G$^{4.3.2}$ G$^{5.4}$ R. S^{3}.	672	A = 31 Cor. Bor.	
A. N. H$^{3.2}$ G$^{5.4.2.1}$ W. .	673	Pr. ✳ = 5 mag.: [$-7^{s}.9 : +19''$, 1885. [G^{5} = same size as foll.	
N. H^{2} G$^{5.4.2.1}$ W. O^{1} .	674		
C. B. H$^{4.3.2}$ G$^{5.2.1}$ Rd. .	675		
E. C. B. H^{3} G$^{5.4.2.1}$ W.	676	[$-1^{s}.20 : -13''.1$, 1885.	
A. E. C. B. N. H$^{3.1}$.	677	Pr. ✳ = 6–7 mag.:	
B. H^{4} G$^{4.3}$ W. R. . .	678	Not binary but common μ.	
G$^{5.2}$ Rd. R. . . .	49		
A. B. H^{1} G$^{5.4.3.2.1}$ W. .	51		
H$^{4.2}$ G$^{5.3}$ R. S^{2} . .	679		
A. O$^{1.2}$ M.	680		
A. E. B. H$^{4.3.2}$ G$^{5.4.3.2}$.	681		
N. H^{2} G$^{5.4.3}$ W. R. .	682		
H$^{4.3.2}$ G$^{5.3.2.1}$ W. R. S^{2}.	683		
B. H$^{4.3}$ G$^{5.4}$ Rd. R. .	56		
H^{2} G^{3} W. O. R. . .	684		
A. E. C. B. H$^{4.3.2.1}$ G$^{5-1}$	685		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
686	17 Can. Ven. . .	6–7	13 04 46.3	+ 2.761	+ 39 06 37	—19.21	1.29
687	*Groom. 2006* .	7	06 47.6	— 9.621	+ 88 15 59	19.22	33.06
688	β Comæ . . .	4	06 30.4	+ 2.806	+ 28 27 41	18.32	1.14
689	*B. A. C.* 4433 .	5	08 30.0	2.729	+ 40 45 43	19.15	1.32
690	19 *Can. Ven.* . .	6–7	10 21.7	2.717	+ 41 27 46	19.12	1.33
691	20 Can. Ven. . .	5–4	13 12 23.0	+ 2.700	+ 41 10 41	—19.03	1.33
692	61 Virginis . . .	5–4	12 23.4	3.130	— 17 40 16	20.10	1.05
693	γ Hydræ . . .	3	12 40.3	3.253	— 22 33 50	19.06	1.08
694	ι *Centauri* . .	3	14 08.3	3.354	— 36 06 18	19.12	1.24
695	23 *Can. Ven.* . .	6–5	13 15 09.9	2.702	+ 40 45 17	18.99	1.32
70	α **Urs. Min., S. P.**	2	1 16 35.8	+22.048	+ 91 18 16	—18.97	43.93
696	63 *Virginis* . .	6	13 16 51.6	3.207	— 17 07 57	18.93	1.05
71	ψ **Cassiop., S. P.**	5	1 17 49.2	4.158	+112 28 15	18.92	2.62
697	α Virginis . . .	1	13 19 08.1	3.153	— 10 33 39	18.91	1.02
698	ζ[1] Urs. Maj. . .	3–2	19 17.7	2.429	+ 55 31 34	18.91	1.77
699	*Groom. 2007* .	7–6	13 19 19.6	— 2.500	+ 85 21 20	—18.87	12.35
700	*i Virginis* . .	6–5	20 38.9	+ 3.161	— 12 06 33	18.87	1.02
701	κ Octantis . . .	5	13 22 31.3	8.555	— 85 11 44	18.81	11.94
75	**38 Cassiop., S. P.**	6–5	1 22 41.0	4.370	+110 19 40	18.69	2.88
702	70 *Virginis* . .	5–6	13 22 48.4	2.934	+ 14 23 37	19.62	1.03
703	**Groom. 2001.**	6	13 23 12.1	+ 1.518	+ 72 59 20	—18.77	3.42
704	69 Urs. Maj. . .	5–6	24 13.8	2.213	+ 60 32 24	18.71	2.03
705	*B. A. C.* 4513 .	6	25 25.1	2.847	+ 24 49 50	18.67	1.10
706	73 *Virginis* . .	6	25 50.9	3.229	— 18 08 08	18.67	1.08
707	*h Virginis* . .	5–6	26 54.6	3.152	— 9 34 19	18.67	1.01
708	ζ Virginis . .	3–4	13 28 50.0	+ 3.053	— 0 00 26	—18.49	1.00
80	**40 Cassiop., S. P.**	6	1 29 20.6	4.670	+107 32 48	18.54	3.32
709	*B. A. C.* 4536 .	5	13 29 39.7	2.683	+ 37 46 19	18.55	1.26
710	24 *Can. Ven.* . .	5	29 45.2	2.461	+ 49 36 15	18.57	1.55
711	*B. A. C.* 4541 .	6–5	30 25.2	3.304	— 25 54 41	18.60	1.11
712	25 Can. Ven. . .	5	13 32 21.2	+ 2.677	+ 36 52 49	—18.42	1.25
713	ε *Centauri* . .	2–3	13 32 36.4	3.749	— 52 52 52	18.55	1.65
86	**43 Cassiop., S. P.**	6	1 33 50.1	4.359	+112 32 21	18.40	2.61
714	*W. B. XIII*, 557 .	6	13 33 54.5	2.965	+ 11 19 50	18.40	1.02
715	**Groom. 2029.**	6	13 34 25.3	1.432	+ 71 49 39	18.37	3.21

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
B. $G^{5.4}$ Rd. R.	686	[$-22^s + 2'.2$. 15 Can. Ven. = 5–6 mag.:	
G^3 Rd. R.	687		
C. B. $H^{4.3.2}$ $G^{5.3}$ W.	688	B = 43 Comæ.	
$H^{4.2}$ $G^{2.1}$ W. Rd. R.	689		
G^4 Rd. R. $S^{2.1}$	690		
A. B. $G^{5.2.1}$ S^3 Rd. R.	691		
C. H^3 $G^{4.2.1}$ W. Rd. R.	692		
B. G^3 W. Bk. R.	693		
H^3 G^1 M. Gi.	694		
G^4 Rd. R. S^3	695		
A. E. C. B. N. $H^{4.2.1}$ G^{5-1}	70		
$H^{4.2}$ G^4 R.	696		
B. $H^{4.3}$ $G^{5.4.3.2.1}$ Rd.	71		
A. E. C. B. N. $H^{4.2.1}$ G.	697		
C. B. $H^{4.3}$ $G^{5.4.2.1}$ W.	698	[$+0^s.94 : -12''.3$ G^5. $\zeta^3 = 5$–6 mag.:	
$H^{3.1}$ $G^{5.4.3.2.1}$ W. Rd.	699	$H^1 = 214$ Camelop.	
N. H^3 $G^{5.3}$ W. R.	700		
A. O^1	701		
A. N. $H^{4.2}$ $G^{5.4.2}$ Rd.	75		
$H^{4.2}$ $G^{5.4.3}$ Rd. R.	702		
B. H^4 $G^{4.3}$ W. Rd. R.	703	D = 7¼ mag.: R = 5–9 mag.: pr. ✻ = 8–9 mag.:	
B. H^3 R.	704	$-4^s.9 : -12''.5$, 1864. S^3 = 7–8 mag.:	
$H^{4.2}$ $G^{5.4}$ S^3	705	foll. ✻ = 8.1 mag.	
$G^{3.2}$ R.	706	$+23^s.2 : -1'\ 4''$ Rd.	
N. $H^{3.2}$ $G^{5.4.3.1}$ W. O^1	707		
A. C. B. N. $H^{4.3.2.1}$ G^{5-1}	708		
B. $G^{5.4.3.1}$ Rd.	80		
A. B. H^3 G^3 W. Rd.	709	B = 17 Can. Ven.	
G^3 $S^{2.1}$	710		
H^3 W. R.	711	[$-0^s.17 : +10''.6$, 1860. Pr. ✻ = 7½ mag.:	
C. $H^{4.3.2}$ $G^{5.1}$ W. R. S^3	712		
O^1 M.	713		
B. H^4 $G^{5.3.2}$ W. Rd. R.	86		
H^3 $G^{4.3}$ R. S^3	714		
B. H^4 G^5 Rd.	715		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
716	*m* Virginis. . .	6–5	13 35 34.6	+3.143	− 8 07 20	−18.30	1.01
717	83 *Virginis* . .	6	38 17.6	3.228	− 15 36 02	18.27	1.04
718	87 *Virginis* . .	6	41 10.1	3.253	− 17 07 02	18.18	1.05
719	τ Bootis . . .	5–4	41 47.8	2.851	+ 18 01 49	18.06	1.05
720	η Urs. Maj. . .	2	43 00.6	2.372	+ 49 53 15	18.09	1.55
721	89 Virginis . .	5	13 43 37.4	+3.248	− 17 32 28	−18.08	1.05
722	*B. F.* 1901 . .	6	44 37.0	+2.868	+ 19 12 05	18.00	1.06
723	*Groom. 2063* .	6	45 38.9	−2.037	+ 83 19 47	18.01	8.61
724	*k* *Centauri* . .	4–5	46 35.6	+3.435	− 31 21 34	17.93	1.17
725	*B. F.* 1907 . .	6–5	46 43.1	+2.652	+ 35 00 51	17.92	1.22
726	*i* **Draconis** . .	5	13 48 04.4	+1.751	+ 65 17 30	−17.88	2.39
727	ζ *Centauri* . .	3	48 22.2	3.710	− 46 43 16	17.87	1.46
728	η Bootis . . .	3	49 12.6	2.857	+ 18 58 29	18.18	1.06
729	9 *Bootis* . . .	5	51 19.5	2.742	+ 28 03 23	17.78	1.13
730	48 *Hydræ* . . .	6	13 53 33.8	3.349	− 24 26 54	17.73	1.10
104	**50 Cassiop., S. P.**	4	1 53 37.8	+5.002	+108 08 09	−17.66	3.21
731	θ Apodis . . .	5	13 54 09.5	5.652	− 76 14 26	17.62	4.20
732	β Centauri . .	1	55 42.8	4.174	− 59 49 03	17.60	1.99
733	τ Virginis. . .	4–5	55 47.6	3.050	+ 2 06 04	17.62	1.00
734	11 Bootis . . .	6	55 58.6	2.722	+ 27 56 33	17.53	1.13
735	*B. A. C.* 4679 .	6–7	13 58 13.7	+3.245	− 14 24 59	−17.47	1.03
736	π Hydræ . . .	4–3	59 49.6	3.407	− 26 07 43	17.52	1.11
737	θ Centauri . .	3–2	13 59 55.1	3.510	− 35 48 16	18.01	1.23
738	α **Draconis** . . .	3–4	14 01 16.6	1.623	+ 64 55 32	17.30	2.36
112	*Gr. 454, S. P.* .	6–7	2 02 46.1	5.374	+106 30 50	17.24	3.52
739	*B. A. C.* 4699 .	6–5	14 03 19.9	+2.409	+ 44 24 05	−17.37	1.40
740	*d* Bootis . . .	5	14 05 09.3	2.739	+ 25 38 13	17.19	1.11
114	**55 Cassiop., S. P.**	6	2 05 28.2	4.631	+114 00 57	17.11	2.46
741	κ Virginis. . .	4–5	14 06 45.7	3.193	− 9 44 17	16.94	1.01
742	14 *Bootis* . . .	6–5	08 33.4	2.885	+ 13 29 57	16.92	1.03
743	δ Octantis . .	5	14 08 36.5	+8.903	− 83 08 21	−17.01	1.03
744	**4 Urs. Min.,** . .	5	09 18.8	−0.334	+ 78 04 58	16.91	4.84
745	ι Virginis. . .	4	09 59.0	+3.138	− 5 27 05	17.34	1.01
746	α Bootis . . .	1	10 25.0	+2.735	+ 19 46 54	18.89	1.06
747	λ Bootis . . .	4	14 12 00.7	+2.285	+ 46 36 58	16.72	1.46

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. C. N. $H^{4.2}$ $G^{5.4.3.2.1}$.	716		
N. $H^{4.2}$ $G^{4.3}$ W. O^{1}.	717		
N. $H^{4.2}$ $G^{4.3}$ O^{1} R.	718		
E. B. $G^{5.4.3.2.1}$ W. R. S.	719		
A. E. C. B. N. $H^{4.3.2.1}$.	720		
B. $G^{4.2.1}$ W. Rd. R.	721		
H^{3} G^{3} S^{2}	722	$S^{2} = 7.2$ mag.	
H^{3} $G^{5.4}$ W. Rd.	723		
$H^{4.2}$ $G^{2.1}$	724		
G^{4} W. S^{2}	725		
B. $H^{4.3}$ $G^{5.2.1}$ W. R.	726		
O^{1} M.	727		
A. E. C. B. N. $H^{4.3.2.1}$.	728		
$H^{4.2}$ $G^{5.4.3}$ R. S^{2}	729		
H^{2} G^{4} W. R.	730		
A. B. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$	104		
A. O^{1} M.	731		
A. E. C. N. O^{1} M.	732		
E. C. B. $H^{4.3.2.1}$ $G^{5.4.3.2}$.	733		
B. $G^{5.4}$ W. R.	734		
H^{2} G^{5} R.	735		
A. $G^{3.2}$ W. Rd. R.	736		
C. $H^{4.3.2}$ $G^{4.3.2.1}$ W. O^{1}.	737		
A. E. C. B. N. $H^{4.3.2}$ G.	738		
H^{3} G^{5} Rd.	112		
H^{2} $G^{5.4}$ Rd. R. $S^{2.1}$	739		
A. B. $H^{4.2}$ $G^{5.4.2.1}$ W.	740		
B. $H^{4.2}$ $G^{5.4.1}$ Rd. R.	114		
A. C. B. N. H^{2} $G^{5.4.3.2.1}$	741		
$H^{4.2}$ $G^{5.4}$ W. R. S^{2}.	742		
A. O^{1} M.	743		
A. B. H^{4} $G^{5.2}$ W.	744		
B. $G^{2.1}$ Rd. R.	745		
A^{1} E.C.B.N.$H^{4.2.1}$ $G^{5.4}$	746		
A. B. $G^{5.2.1}$ W. Rd. R.	747		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
748	ι Bootis . . .	4–5	14 12 05.6	+2.127	+ 51 53 53	—16.73	1.58
749	λ Virginis. . .	5–4	12 53.3	3.237	— 12 50 29	16.76	1.02
750	*B. A. C.* 4757 .	6	15 26.5	3.581	— 34 15 38	16.44	1.21
751	2 *Libræ* . . .	6	17 14.4	3.220	— 11 11 18	16.64	1.02
752	*B. A. C.* 4776 .	6–7	14 19 10.1	3.443	— 26 19 46	16.54	1.12
126	ι **Cassiop.**, S. P.	4	2 19 35.8	+4.856	+113 06 56	—16.45	2.55
753	*f Bootis* . . .	5	14 21 06.6	2.796	+ 19 44 40	16.33	1.06
754	θ Bootis . . .	4–3	21 17.0	2.044	+ 52 22 57	16.77	1.64
755	φ Virginis. . .	5	22 16.6	3.085	— 1 42 43	16.32	1.00
756	*B. A. C.* 4797 .	6	23 30.9	2.496	+ 36 42 42	16.28	1.25
757	*B. A. C.* 4805 .	6–7	14 25 04.9	+2.366	+ 42 18 59	—16.40	1.35
758	ρ Bootis . . .	4–3	14 26 52.5	2.588	+ 30 52 36	15.97	1.18
133	**36 Cassiop.**, S. P.	6–5	2 27 07.2	5.574	+107 41 09	16.08	3.29
759	γ Bootis . . .	3–2	14 27 27.0	+2.422	+ 38 48 42	15.90	1.28
760	**5 Urs. Min.** . .	5–4	27 46.8	—0.195	+ 76 12 26	16.01	4.19
761	η *Centauri* . .	3	14 28 12.6	+3.786	— 41 39 05	—16.00	1.34
762	Groom. 2125 .	6	28 35.5	1.622	+ 60 43 57	16.01	2.05
763	σ *Bootis* . . .	5–4	14 29 40.4	2.613	+ 30 14 43	15.87	1.16
137	***Gr. 527, S. P.*** .	6	2 31 17.3	8.249	+ 99 02 28	15.84	6.36
764	α^2 Centauri . .	1	14 31 48.8	4.043	— 60 21 46	15.39	2.02
765	3 *Libræ* . . .	6–7	14 32 43.4	+3.444	— 24 31 48	—15.84	1.10
766	*Piaz. XIV*, 140	6	32 53.2	2.789	+ 18 47 58	15.76	1.06
767	α Apodis . . .	5–4	33 37.4	7.150	— 78 33 17	15.75	5.04
768	α *Lupi* . . .	3	34 17.1	3.959	— 46 53 36	15.71	1.46
769	33 Bootis . . .	5–6	14 34 33.4	2.234	+ 44 54 04	15.73	1.41
142	**Brad. 366**, S.P.	7–6	2 34 56.7	+5.073	+112 39 54	—15.61	2.60
770	π Bootis (pr.) .	4	14 35 19.3	2.818	+ 16 54 42	15.63	1.05
771	ζ Bootis . . .	3–4	35 39.4	2.862	+ 14 13 21	15.60	1.03
772	μ Virginis. . .	4	37 00.0	3.157	— 5 09 27	15.86	1.00
773	34 *Bootis* . . .	5–4	38 22.5	2.643	+ 27 01 03	15.47	1.12
774	ϵ^2 Bootis . . .	2–3	14 39 57.9	+2.621	+ 27 33 34	—15.35	1.13
775	109 Virginis. . .	4–3	40 26.2	3.030	+ 2 22 39	15.36	1.00
776	μ *Libræ* . . .	6–5	43 00.9	3.279	— 13 40 09	15.22	1.03
777	8 Libræ . . .	6	44 19.6	3.306	— 15 31 07	15.21	1.04
778	α^2 Libræ . . .	2–3	14 44 31.0	3.309	— 15 33 48	15.18	1.04

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
B. G^3 Rd. R. . . .	748	[$+2^s.0:-26''$. Comp. = 8 mag.:	
A. C. N. $H^{4.3.2}$ $G^{5.4}$ W.	749		
$H^{4.2}$ W.	750		
N. $H^{4.2}$ $G^{5.4.2.1}$ W. . .	751		
W. Rd. R. . . .	752		
A. B. N. $H^{4.3.2}$ $G^{5.4.3}$.	126	Foll. ✱ $+1^s.30:-2''.0$ G^5	
H^3 $G^{5.4.3.2}$ R. S^2 . .	753		
A. B. N. $H^{4.3.2}$ $G^{5.4.1}$.	754		
B. G^3 R.	755		
$H^{4.2}$ G^5 W. $S^{2.1}$ . .	756		
H^2 $G^{4.3}$ W. Rd. $S^{2.1}$.	757		
A. E. C. B. $H^{4.3.2.1}$ G^{5-1}	758		
B. $H^{4.3}$ G^3 Rd. R. .	133		
B. $H^{4.3.2}$ $G^{2.1}$ W. Bk. .	759		
A. N. $H^{4.2}$ $G^{5.4.2.1}$ W. .	760		
O^1 M.	761		
B.Rd. R.	762		
H^3 $G^{4.1}$ W. R. S^2 . .	763		
H^1 $G^{3.2.1}$ Bk. Rd. . .	137		
A. E. C. N. $O^{2.1}$ M. .	764	[$-0^s.2:+0''.9$. $O^1=a^1$, 4 mag.:	
W. R.	765		
$G^{4.2}$ R. S.	766	R = 3090.	
A. M.	767		
M.	768		
A. B. G^1 Bk. Rd. R. .	769		
B. H^4 $G^{4.3}$ W. Rd. R. .	142	[$+0^s.5:-2''.0$ (6 mag.: Wb.)	
B. $H^{4.3.2}$ G^2 W. Bk. .	770	$G^2=\pi^2$ 4 mag.:	
C. B. $H^{4.2}$ $G^{5.3.2.1}$ W. .	771	B = mean, 2d ✱ 4.5 mag.:	
B. $H^{3.2}$ $G^{5.4.3.2.1}$ W. .	772	[$+0^s.06+0''.6$ [only elong. in 4-in. obj.	
H^2 $G^{5.3}$ W. R. S^2. . .	773		
A. E. C. N. $H^{4.3.2.1}$ $G^{5.4}$	774	{$\varepsilon^1=7$ mag. $-0^s.1+2''.4$ {Test for 2¼-in. teles.	
B. $H^{4.3.2}$ G^2 Bk. R. .	775		
N. H^2 $G^{4.3.2.1}$ W. R. .	776	[$-0^s.04:+1''.2$ (1874). Star 6½ mag. =	
B. $G^{5.3.2.1}$ W. R. . .	777		
A. E. C. B. N. $H^{4.2.1}$.	778	[$-11^s.4:+2'\,40''.8$ (1885) $a^1=6$ mag.:	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
779	ξ *Bootis* . . .	3-4	14 46 05.1	+ 2.767	+ 19 34 39	—15.10	1.06
780	ξ¹ *Libræ* . . .	6	48 08.3	3.248	— 11 25 42	14.92	1.02
781	Groom. 2164 .	6	48 31.4	1.516	+ 59 45 42	14.70	1.99
782	ξ² Libræ . . .	6-5	50 31.7	3.247	— 10 56 40	14.76	1.01
783	212 Piazzi XIV. .	6	50 45.0	3.487	— 20 53 43	16.43	1.07
784	221 Piazzi XIV. .	6	14 50 47.6	+ 2.829	+ 14 54 42	—14.73	1.03
158	**47 Cephei, S. P.** .	6-5	2 50 50.6	7.701	+101 02 15	14.73	5.22
785	β *Lupi* . . .	3-4	14 51 01.0	+ 3.899	— 42 40 11	14.88	1.36
786	β **Urs. Min.** . .	2	51 02.9	— 0.235	+ 74 37 34	14.72	3.77
787	κ *Centauri* . .	3	51 40.9	+ 3.877	— 41 38 30	14.70	1.34
788	*B. A. C.* 4937 .	5-6	14 52 33.8	+ 1.982	+ 50 05 56	—14.88	1.56
789	δ *Libræ* . . .	4-5	54 49.7	3.198	— 8 03 43	14.50	1.01
790	**2 Urs. Min.** . .	5	55 45.5	0.942	+ 66 23 27	14.38	2.40
791	20 Libræ . . .	3-4	57 20.4	3.498	— 24 49 45	14.40	1.10
792	β Bootis . . .	3	57 36.9	2.260	+ 40 50 40	14.37	1.32
793	ψ Bootis . . .	4-5	14 59 31.1	+ 2.570	+ 27 23 48	—14.21	1.13
794	c *Bootis* . . .	5-4	15 02 15.0	+ 2.633	+ 25 19 03	14.20	1.11
795	***Groom. 2213*** .	7-6	03 21.3	— 6.701	+ 84 23 45	13.97	10.24
796	ι¹ Libræ . . .	5-4	15 05 40.0	+ 3.409	— 19 21 21	13.88	1.06
171	**48 Cephei, S. P.** .	6-7	3 05 45.7	7.391	+102 41 26	13.77	4.55
797	1 *Lupi* . . .	6	15 07 34.7	+ 3.658	— 31 05 21	—13.73	1.17
798	γ *Triang. Aus.* .	3-4	08 11.4	5.510	— 68 15 11	13.71	2.70
799	*B. A. C.* 5026 .	6	09 12.8	2.285	+ 38 41 46	13.60	1.28
800	3 Serpentis . .	6	09 28.4	2.978	+ 5 22 01	13.58	1.00
801	*B. A. C.* 5023 .	6	09 42.9	3.461	— 21 59 41	13.66	1.08
802	β Libræ . . .	2	15 10 49.1	+ 3.221	— 8 57 28	—13.53	1.01
803	δ Bootis . . .	3	10 52.0	2.421	+ 33 44 40	13.58	1.20
804	**1 Urs. Min.** . .	5-6	13 19.2	0.663	+ 67 47 01	13.73	2.64
805	5 *Serpentis* . .	5-6	13 25.9	3.042	+ 2 12 17	13.85	1.00
806	δ *Lupi* . . .	4-5	13 49.5	+ 3.920	— 40 13 48	13.31	1.31
807	**57 Urs. Min.** . .	6-7	15 14 36.4	—21.642	+ 87 40 26	—13.21	24.64
808	φ² *Lupi* . . .	5-6	15 48.6	+ 3.813	— 36 26 45	13.24	1.24
809	σ² *Libræ* . . .	6-5	16 36.9	3.337	— 14 43 22	13.18	1.03
810	ρ Octantis . .	6	16 56.1	12.875	— 84 04 42	13.08	9.69
811	ε *Libræ* . . .	5-6	15 17 57.9	+ 3.244	— 9 54 30	13.18	1.01

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
$H^{4.3.2}$ $G^{5.3}$ Bk. R. . .	779	G^{3} = 2d star 6–5: [+$0^{s}.1$: −6″.0.	
N. H^{2} $G^{5.4}$ R. . . .	780		
B. $H^{4.3.2}$ G^{3} Rd. R. S. .	781		
C. N. H^{2} $G^{5.4.3.2.1}$ W. .	782		
C. $G^{5.3.1}$ W. O^{1} R. .	783	W = pr. star = 7–8 mag.: [−$1^{s}.0$: + 4″.2.	
B. R. S^{2}	784		
A. B. $H^{4.2}$ $G^{5.4.2}$ W. .	158		
O^{1} M.	785		
A. E. C. B. N. $H^{4.3.2.1}$	786		
O^{1} M.	787		
G^{1} W. Rd. R. $S^{2.1}$ . .	788	Piazzi XIV, 235. Gr. 2171.	
$H^{4.2}$ $G^{5.3.2.1}$ W. Rd. R.	789		
B. H^{4} $G^{5.3}$ Rd. . .	790	G^{5} = Piaz. XIV, 260.	
A. C. B. N. H^{3} $G^{4.2.1}$.	791	A + B + N = ν Scorp.	
A. C. B. N. $H^{4.2}$ G^{5-1} .	792		
E. C. B. $H^{4.3.2.1}$ $G^{5.4.3.2.1}$	793		
$H^{4.3.2}$ G^{3} W. R. S^{3} .	794		
G^{5} W. Rd. R. . . .	795		
B. N. $H^{4.2}$ $G^{5.4.3.2.1}$ W.	796		
A. B. N. $H^{4.3.2}$ G^{5} W. .	171		
$H^{4.2}$ G^{4} W. . . .	797		
$O^{2.1}$ M.	798		
G^{4} W. Rd. S^{2} . . .	799		
B. $G^{4.1}$ W. R. . . .	800		
H^{3} $G^{5.3}$ R.	801	Piaz. XV, h. 19.	
A. E. C. B. N. $H^{4.3.2.1}$.	802		
A. C. B. $H^{4.3.2}$ $G^{5.4.3.2.1}$.	803	Comp. = 8½ mag. [+ $8^{s}.6$: + 28″.4.	
B. H^{4} $G^{5.4.2}$ Rd. . .	804	G^{5} = Groom. 2214.	
H^{3} W. R.	805		
H^{2} O^{1} M.	806	Not δ Lupi of $G^{2.1}$.	
C. $H^{3.1}$ $G^{5.4.3.2}$ W. Rd.	807	Gr. 2283, B. A. C. 5140, [c = 6 mag.	
H^{2} $G^{3.1}$ W. O^{1} . .	808		
N. $G^{4.3}$ W. R. . . .	809		
A. O^{1} M.	810		
$H^{4.2}$ G^{4} W. R. . . .	811		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
812	η Coronæ . . .	5	15 18 27.2	+ 2.479	+ 30 42 14	—13.17	1.16
813	μ¹ Bootis . . .	4–3	20 08.8	2.266	+ 37 46 52	12.79	1.26
814	τ¹ Serpentis . .	6	20 27.4	+ 2.778	+ 15 50 00	12.86	1.04
815	γ² **Urs. Min.** . .	3	20 55.1	— 0.137	+ 72 14 36	12.81	3.28
816	ζ Libræ . . .	6–7	21 46.3	+ 3.374	— 16 18 53	12.82	1.04
817	ι Draconis . .	3	15 22 22.5	+ 1.338	+ 59 22 10	—12.69	1.96
818	β Coron. Bor.. .	4–3	23 05.3	2.475	+ 29 30 09	12.63	1.15
819	*B. A. C.* 5109 .	6–7	26 00.5	3.437	— 19 16 40	12.51	1.06
820	ν¹ Bootis . . .	4–5	26 47.9	2.153	+ 41 13 33	12.41	1.33
821	ν² Bootis . . .	4–5	27 39.9	2.145	+ 41 17 25	12.35	1.33
822	θ Coron. Bor.. .	4	15 28 17.4	+ 2.415	+ 31 44 51	—12.40	1.18
186	***Gr. 642, S. P.*** .	6	3 28 59.0	19.503	+ 93 43 02	12.21	15.42
823	γ Libræ . . .	4–5	15 29 05.7	3.347	— 14 23 29	12.26	1.03
824	δ² *Serpentis* . .	3–4	29 18.7	2.869	+ 10 55 24	12.20	1.02
825	α Coron. Bor.. .	2	29 49.2	2.539	+ 27 06 08	12.32	1.12
826	14 *Serpentis* . .	6	15 30 34.8	+ 3.076	— 0 10 40	—12.15	1.00
827	ψ¹ *Lupi* . . .	5	32 27.9	3.792	— 34 02 11	12.07	1.21
828	φ Bootis . . .	5	33 41.8	+ 2.154	+ 40 43 41	11.89	1.32
829	θ ***Urs. Min.*** . .	5	34 50.9	— 1.896	+ 77 43 54	11.86	4.71
830	ζ Cor. Bor. foll. .	4	35 02.8	+ 2.256	+ 37 00 35	11.86	1.25
831	κ Libræ . . .	5	15 35 19.3	+ 3.446	— 19 18 18	—11.95	1.06
832	ψ² *Lupi* . . .	5–6	35 21.4	3.806	— 34 20 21	11.91	1.21
833	ι *Serpentis* . .	5–4	36 25.4	2.673	+ 20 02 27	11.78	1.06
834	γ Coron. Bor.. .	4–3	15 37 54.8	2.256	+ 26 39 38	11.62	1.12
194	γ **Camelop., S.P.**	4–5	3 38 13.8	6.216	+109 01 26	11.64	3.06
835	α Serpentis . .	2–3	15 38 36.2	+ 2.951	+ 6 47 17	—11.54	1.01
836	β Serpentis . .	3–4	40 52.8	2.767	+ 15 46 56	11.57	1.04
837	κ Serpentis . .	4	43 33.8	2.698	+ 18 29 51	11.33	1.05
838	μ Serpentis . .	4–3	43 37.2	3.127	— 3 04 38	11.27	1.00
839	12 Draconis . .	5	44 55.0	0.902	+ 62 57 19	11.21	2.20
840	β *Triang. Aus.* .	3	15 45 01.4	+ 5.232	— 63 04 23	—11.57	2.21
841	ε Serpentis . .	3–4	45 05.0	2.987	+ 4 49 29	11.07	1.00
842	λ Libræ . . .	6–5	46 39.4	3.473	— 19 49 20	11.06	1.06
843	κ *Coron. Bor.* .	5–4	46 53.9	+ 2.258	+ 36 00 54	11.33	1.24
844	ζ **Urs. Min.** . .	4–5	15 48 11.3	— 2.256	+ 78 08 52	10.91	4.87

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
C. H^3 $G^{5.3}$ Bk. R. $S^{2.1}$.	812	2d star = 6–5 mag.: [$+0^s.1$: $+0''.7$.	
A. B. N. $H^{3.3}$ $G^{5.4.2.1}$ W.	813	μ^2 = 7 mag. $+1^s.4$ — $1'\ 47''$ [μ^3 double $0''.5$; 8.5 mag.	
B. W. R.	814		
A. C. B. N. $H^{4.3.3}$ G^{5-1}	815	γ^1 6½ mag.: — $223^s.5 \pm 0''$.	
C. N. G^{5-1} W. Rd. R.	816	ζ^1 Libræ = C + N + Rd.	
C. B. H^3 G^{5-1} W. Rd. .	817		
A. B. $H^{4.3}$ $G^{5.2.1}$ R. S^3	818		
N. H^3 $G^{5.3}$ W. R. . .	819		
B. $H^{4.3.3}$ G^3 Rd. R. .	820		
B. $H^{4.3}$ G^3 W. Rd, .	821		
B. H^3 $G^{4.3}$ R. . . .	822		
$H^{2.1}$ $G^{5.4.3.2.1}$ W. Rd. .	186		
B. $G^{5.4.3.2.1}$ W. Rd. R. .	823		
G^3 Bk. R. S^3 . . .	824	Bk = 13 δ: δ^1 = 3–4 mag.: [$+0^s.0$: — $3''.5$.	
A^1 E. C. B. N. $H^{4.3.2.1}$	825		
G^1 Bk. R.	826		
$H^{4.3}$ W.	827		
B. H^3 G^1 W. Bk. Rd.	828		
H^3 $G^{5.4.3.2.1}$ Rd. R. .	829	Groom. 2268.	
B. $G^{5.3}$ Bk. . . .	830	ζ pr. = 4 mag.: — $0^s.4$: $+4''$.	
C. N. $G^{5.4.2.1}$ W. R. .	831		
$H^{4.3}$ G^4	832		
$H^{3.3}$ G^3 R. S^3 . . .	833		
B. $G^{5.3}$ R.	834		
A. B. $H^{4.3}$ $G^{5.4.3}$ W. .	194		
A^1 E. C. B. N. $H^{4.2.1}$.	835	Comp. = 15 mag.: [$+0^s.1$ + $49''.9$.	
B. $H^{4.3.3}$ $G^{4.5.3}$ W. Bk.	836	Comp. = 10 mag.: [— $2^s.1$: — $2''.7$.	
B. $G^{5.4.3}$ W. R. . .	837		
B. $H^{4.3.3}$ G^3 W. Bk. .	838		
B. $G^{5.1}$ R.	839	G^5 = Piaz. XV, 198.	
O^1 M.	840		
A E. B. N. $H^{4.3.3}$ $G^{5.4.3.3}$	841		
C. N. $H^{4.3.3}$ $G^{3.2.1}$ W. .	842		
$G^{5.3}$ R. S^3	843		
A. E. C. B. N. $H^{4.3.3}$ G.	844		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
845	ξ¹ *Lupi* . . .	4–5	15 49 32.4	+ 3.286	− 33 37 39	−10.82	1.20
206	***Gr. 746, S. P.*** .	5–6	3 50 50.8	9.740	+ 99 37 17	10.76	5.97
846	γ Serpentis . .	4–3	15 51 08.5	2.769	+ 16 02 16	11.96	1.04
847	π *Scorpii* . . .	3–4	51 53.7	3.618	− 25 46 55	10.68	1.11
848	ε Coron. Bor.. .	4	52 47.7	2.483	+ 27 12 41	10.63	1.12
849	δ Scorpii . . .	2–3	15 53 32.1	+ 3.538	− 22 17 36	−10.55	1.08
850	49 Libræ . . .	5–6	53 52.2	3.355	− 16 11 36	10.86	1.04
851	Groom. 2296 .	5–6	55 03.6	1.410	+ 55 04 29	10.30	1.75
852	r *Herculis* . .	6–5	56 04.3	2.695	+ 18 08 13	10.16	1.05
853	β¹ Scorpii . . .	2	58 45.1	3.480	− 19 29 23	10.16	1.06
854	θ Draconis . .	4–3	15 59 44.0	+ 1.115	+ 58 52 21	− 9.72	1.93
855	***Rad. 3523*** . .	7–6	16 00 24.1	−12.130	+ 85 37 48	10.00	13.13
215	**Gr. 750, S. P.** .	6–7	4 00 45.8	+17.043	+ 94 44 58	9.99	12.08
856	κ *Herculis* . .	5	16 02 53.1	2.702	+ 17 21 15	9.81	1.05
857	δ¹ Apodis . . .	5–6	03 11.8	8.731	− 78 24 10	9.79	4.98
858	τ *Coron. Bor.* .	4–5	16 04 46.0	+ 2.192	+ 36 47 02	− 9.33	1.25
859	φ Herculis . .	4	05 08.6	1.881	+ 45 14 13	9.60	1.42
860	ν² Scorpii . . .	4–5	05 18.7	3.478	− 19 09 39	9.66	1.06
861	**Groom. 2320**.	6–5	06 00.5	0.138	+ 68 06 48	9.50	2.68
862	δ Ophiuchi . .	3	08 19.2	3.139	− 3 23 51	9.53	1.00
863	σ Cor. Bor. (mean)	6	16 10 22.2	+ 2.242	+ 34 09 02	− 9.24	1.21
864	ε Ophiuchi . .	3–4	12 14.2	+ 3.169	− 4 24 41	9.06	1.00
865	**19 Urs. Min.** . .	6	14 07.0	− 1.786	+ 76 09 59	8.95	4.18
866	σ Scorpii . . .	4–3	14 11.9	+ 3.636	− 25 17 57	8.96	1.10
867	γ Apodis . . .	4–5	15 50.4	8.986	− 78 38 08	8.89	5.08
868	τ Herculis. . .	3–4	16 16 17.1	+ 1.801	+ 46 35 15	− 8.75	1.46
869	γ Herculis . .	3	16 50.8	2.644	+ 19 25 26	8.68	1.06
870	ρ *Ophiuchi* . .	5	18 41.4	3.588	− 23 10 52	8.62	1.09
871	ω Herculis . .	5	16 20 06.5	2.765	+ 14 17 56	8.50	1.03
231	***Gr. 828, S. P.*** . .	6–5	4 20 11.2	+ 6.866	+107 43 14	8.46	3.29
872	η **Urs. Min.** . .	5	16 20 52.6	− 1.825	+ 76 01 12	− 8.13	4.19
873	Groom. 2343 .	6–5	21 54.5	+ 1.309	+ 55 28 01	8.34	1.77
874	α Scorpii . . .	1–2	22 21.4	3.670	− 26 10 33	8.32	1.11
875	η Draconis . .	3–2	22 26.2	0.805	+ 61 46 29	8.23	2.11
876	φ *Ophiuchi* . .	5–4	16 24 33.5	+ 3.427	− 16 21 40	8.16	1.04

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
$G^{4.3}$ W. O^1 . . .	845	[$=+0^s.8:-7''.0$. $G^{2.1}=\xi^2$ Lupi	
H^3 $G^{5.2}$ W. Rd. R. .	206		
B. $H^{4.3.2}$ $G^{5.4.3.2}$ W. R. S^2	846		
N. H^3 $G^{5.4.3}$ W. O^1 M.	847		
A. B. N. $H^{3.2}$ $G^{5.4.3.2.1}$.	848		
A. C. B. N. $H^{4.3.2}$ G^{5-1}	849		
C. $G^{5.3.1}$ W. R. . . .	850		
B. $H^{4.3}$ Rd. S. . . .	851		
$G^{5.4}$ W. R. S^2 . . .	852		
A. E. C. B. N. $H^{4.3.2.1}$ G^4	853	[$+0^s.4:+13''$. β^2 Scorpii $=5$–6 mag.:	
B. $H^{4.3.2}$ $G^{5.2}$ Rd. R. .	854		
G^3 Rd.	855		
C. B. $H^{4.3\ 1}$ $G^{5.4.3}$ W. .	215		
$H^{4.2}$ $G^{5.4}$ W. R. S^2. .	856	[$+0^s.4+30''.5$, Wb. $\kappa^2=7$ mag.	
A. O^1 M.	857	$O^1=\delta^2$ 6 mag.: [$+0^s.7:+1'\ 39''.5$.	
$G^{5.4.3}$ W. R. $S^{2.1}$ . .	858	[$-1^s.2:+36''.8$, G^5	
A. B. $G^{4.3}$ Rd. R. . .	859	Comp. $=7$ mag.:	
C. N. $H^{4.3.2}$ $G^{5.2.1}$ W. O^1	860	subdiv.: 8 mag. $1''.8$, Wb.	
A. N. $H^{4.3}$ $G^{5.4.3.2}$ W. .	861		
A. E. C. N. $H^{4.3.2}$ G^{5-1}	862		
A. C. H^3 $G^{5.2.1}$ W. R. S.	863	[$-0^s.1:-3''.1$, Wb. Comp. $=6\frac{1}{2}$ mag.:	
B. $H^{4.3.2}$ $G^{5.1}$ W. R. .	864		
B. $H^{4.3.2}$ $G^{5.4.1}$ Rd. R. .	865		
C. N. H^2 $G^{5.4.2.1}$ W. O^1	866	[$-1^s.5:-0''.7$, Wb. Comp. $=9\frac{1}{2}$ mag.	
A. O^1 M.	867		
A. B. N. H^2 $G^{5.4.3.2.1}$.	868		
E. B. $H^{3.1}$ G^5 Rd. R. .	869	[comp. double; dark field. [$+0^s.02,+3''.9$: each	
N. H^2 $G^{5.3}$ W. R. . .	870	50 Ophi. 2d $=8$ mag.	
B. $H^{4.3.2}$ $G^{5.3}$ R. S^2 .	871	Comp. $=12$ mag.:	
$G^{2.1}$ Rd.	231	[$+0^s.02,-2''.0$ [1878—5, Burnham.	
A. B. $G^{5.4.3.2.1}$ W. Rd. .	872		
B. $G^{3.1}$	873	[seen with $2\frac{3}{4}$-in. [$-0^s.3+0''.4$ grn.	
A. E. C. B. N. $H^{4.2.1}$ G^{5-1}	874	Comp. $=7$ mag.:	
A. E. C. B. N. $H^{4.3.2}$ $G^{5.4.2}$	875	Dou.: Gr. 2346 $=6$ mag.:	
N. H^2 $G^{5.4.3.2.1}$ W. .	876	[$-9^s.6+11'\ 0''.3$.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
877	λ Ophiuchi	4-3	16 25 06.8	+ 3.024	+ 2 14 13	— 8.11	1.00
878	β Herculis	2-3	25 16.6	2.577	+ 21 44 27	8.07	1.07
879	*n Herculis*	6-5	26 56.2	+ 2.953	+ 5 46 01	7.97	1.01
880	**A Draconis**	5	28 12.9	— 0.137	+ 69 01 00	7.80	2.79
881	τ Scorpii	3-4	28 43.5	+ 3.727	— 27 58 35	7.82	1.13
882	σ Herculis	4	16 30 23.8	+ 1.931	+ 42 40 29	— 7.63	1.36
883	ζ Ophiuchi	3-2	30 49.6	3.299	— 10 20 00	7.59	1.01
884	*B. A. C.* 5568	6-7	16 32 50.0	1.747	+ 46 50 46	7.47	1.46
245	**Gr. 848,** S. P.	6	4 33 22.7	7.975	+104 16 11	7.58	4.06
885	24 *Scorpii*	5	16 34 55.3	+ 3.462	— 17 31 05	7.26	1.05
886	**Groom. 2373**	6	16 35 35.2	— 2.774	+ 77 40 17	— 7.21	4.68
887	ε Triang. Aus.	2	36 29.8	+ 6.295	— 68 48 52	7.20	2.77
888	ζ Herculis	3-2	16 36 57.1	2.263	+ 31 48 43	6.66	1.18
250	***Gr. 856,** S. P.*	5-6	4 38 51.9	10.990	+ 99 00 00	6.95	6.39
889	η Herculis	3	16 38 57.2	2.054	+ 39 08 29	7.03	1.29
890	18 *Draconis*	5-6	16 40 07.4	+ 0.400	+ 64 48 26	— 6.87	2.35
253	**α Camelop.,** S.P.	4	4 42 37.2	5.922	+113 51 16	6.64	2.47
891	ε Scorpii	3	16 42 43.0	3.875	— 34 05 02	6.97	1.21
892	Groom. 2377	5	43 07.0	1.133	+ 56 59 15	6.56	1.84
893	20 *Ophiuchi*	5	43 28.3	3.313	— 10 34 41	6.65	1.01
894	μ^1 *Scorpii*	3	16 44 04.7	+ 4.053	— 37 45 22	— 6.66	1.26
895	***Groom. 2388***	7-6	44 30.1	— 1.368	+ 74 05 44	+ 6.49	3.65
896	*k Herculis.*	6-5	44 44.4	+ 2.912	+ 7 26 50	— 6.45	1.01
897	ζ^2 *Scorpii*	3	46 29.2	4.201	— 42 09 45	6.52	1.35
898	49 Herculis	6	46 50.7	2.728	+ 15 10 05	6.28	1.04
899	51 *Herculis*	6-5	16 46 59.2	+ 2.484	+ 24 51 13	— 6.27	1.10
900	ι *Ophiuchi*	4-5	48 34.0	2.835	+ 10 21 18	6.17	1.02
901	54 *Herculis*	6-5	16 50 18.9	2.633	+ 18 37 07	5.95	1.06
262	***Rad. 1311,** S. P.*	6-7	4 51 07.8	20.489	+ 94 11 37	5.94	13.68
902	κ Ophiuchi	3-4	16 52 13.5	2.837	+ 9 33 17	5.82	1.01
903	30 *Ophiuchi*	6-5	16 54 59.8	+ 3.156	— 4 02 57	— 5.67	1.00
904	ε Herculis	3-4	55 58.3	2.293	+ 31 05 48	5.49	1.17
905	*d* Herculis	5	57 21.6	+ 2.211	+ 33 44 09	5.41	1.22
906	**ε Urs. Min.**	4-5	16 57 47.3	— 6.345	+ 82 13 29	5.38	7.39
907	60 Herculis	5	17 00 02.7	+ 2.780	+ 12 53 58	5.18	1.03

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
C. B. H$^{4.3.2}$ G$^{5.4.3.2.1}$ R.	877	[+0^s.05 + 0''.9 yl. bl. Comp. = 6 mag.: Hind's period 95.9 years.	
A. C. B. N. H^{3} G$^{5.2}$.	878		
H^{2} G^{4} R.	879		
A. B. N. H$^{4.3.2}$ G$^{5.4.3}$.	880		
C. N. H$^{4.3.2}$ G$^{5.4.3.2.1}$ W.	881		
B. G$^{5.2.1}$ W. Rd. R. .	882		
A. E. B. N. H$^{4.3.2}$ G$^{5-1}$.	883		
H^{2} Rd. S$^{2.1}$ . . .	884		
B. H^{2} G$^{5.4.2}$ Rd. R. .	245		
H$^{4.3}$ G$^{5.4}$ W. R. . .	885		
B. H$^{4.2}$ G^{5} Rd. . .	886		
A. E. N. O$^{2.1}$ M. . .	887		
E. C. B. H$^{4.3.2.1}$ G$^{5.4.2.1}$	888	[+0^s.0: —1''.0 per. 35yrs. Comp. = 6 mag.:	
H^{3} G$^{5.2.1}$ W. Rd. R. .	250		
A.B.N.H$^{4.3.2}$ G$^{5.4.2.1}$ W.	889		
G$^{5.4.3.2.1}$ W. Rd. R. S^{2} .	890		
A. B. N. H$^{4.3.2}$ G$^{5-2}$ Rd.	253		
C. H$^{3.2}$ G$^{5.4.3.2.1}$ W. O^{1}.	891		
B. H$^{4.2}$ G$^{5.4.3}$ Rd. R. S$^{2.1}$	892		
G$^{4.3}$ W. R.. . . .	893		
W. O^{1}	894		
Rd.	895		
H^{2} G^{3} R.	896		
H^{3} O^{1}	897	[—36^s.7: —25''.8. ζ^1 = 4½ mag.:	
B. H$^{4.3}$ G$^{5.4.2.1}$ R. S^{2} .	898	G^{4} = var. S Herc = —11^s.0, [—1''.54; var. 5.9–12.2 [per. 303 days, G^{5}.	
—			
H^{2} G^{4} W. R. S^{2} . .	899		
H$^{4.3}$ G$^{2.1}$ W. Bk. R. S^{2}	900	H^{2} = *i*.	
H^{2} G$^{5.1}$ W. R. S^{2} . .	901		
G^{4} Rd.	262		
A. E. C. B. N$^{4.3.2.1}$ G^{5} .	902		
H$^{3.2}$ G^{1} W. Bk. R. .	903		
C. B. H$^{4.3.2}$ G$^{5.4.3.2.1}$ W.	904		
A. H^{2} G$^{5.4.3.1}$ N. W. .	905		
A. E. C. B. N. H$^{4.3.2.1}$ G	906		
B. H^{2} G^{3} W. R. S^{2} .	907		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
908	*B. A. C.* 5774 .	6–5	17 02 17.8	+ 3.091	− 0 55 35	− 5.00	1.00
271	**19 Camelop., S.P.**	5	5 03 37.5	9.768	+100 54 15	5.03	5.29
909	η Ophiuchi . .	2–3	17 03 47.0	3.435	− 15 34 53	4.79	1.04
910	Groom. 2415 .	6	04 01.6	1.950	+ 40 40 00	4.86	1.32
911	*B. A. C.* 5795 .	6–7	05 28.0	1.473	+ 50 59 17	4.74	1.59
912	*B. A. C.* 5804 .	6	17 07 46.2	+ 3.934	− 33 24 52	− 4.59	1.20
913	A¹ Ophuichi . .	6	08 16.7	3.684	− 26 25 57	5.65	1.12
914	ζ **Draconis** . .	3	08 27.3	0.167	+ 65 51 25	4.41	2.45
915	α¹ Herculis . .	Var.	09 24.2	2.733	+ 14 31 20	4.37	1.03
916	δ Herculis . .	3	10 18.3	2.459	+ 24 58 32	4.47	1.10
917	π Herculis . .	3–4	17 11 02.4	+ 2.088	+ 36 56 22	− 4.24	1.25
918	*u Herculis* . .	4	13 04.5	2.211	+ 33 13 28	4.11	1.20
919	θ Ophiuchi . .	3–4	14 56.8	3.679	− 24 52 41	3.97	1.10
920	γ *Aræ*	3	15 42.9	5.033	− 56 16 03	3.93	1.80
921	β *Aræ*	3	15 44.6	4.978	− 55 25 09	3.85	1.76
922	ω Herculis . .	5–6	17 16 21.4	+ 2.242	+ 32 37 00	− 4.84	1.19
923	b Ophiuchi . .	5	19 20.8	3.659	− 24 04 06	3.67	1.10
924	d Ophiuchi . .	4–5	20 00.6	3.823	− 29 45 43	3.66	1.15
925	δ Aræ	4	20 43.3	5.400	− 65 35 11	3.57	2.42
926	σ Ophiuchi . .	5–4	20 48.5	2.976	+ 4 14 29	3.39	1.00
927	υ *Scorpii* . . .	3	17 22 56.7	+ 4.075	− 37 12 12	− 3.32	1.26
928	α *Aræ*	3	22 57.2	4.627	− 49 46 59	3.31	1.55
929	κ Herculis . .	6	17 23 41.3	1.586	+ 48 21 25	3.20	1.50
290	**Gr. 966, S. P.** .	6–7	5 24 21.6	7.999	+105 02 06	3.13	3.86
291	**64 Camelop., S.P.**	6–7	5 25 14.3	18.604	+ 94 51 51	3.03	11.79
930	λ *Scorpii* . . .	3	17 25 48.0	+ 4.068	− 37 01 08	− 3.01	1.25
931	λ *Herculis* . .	5–4	26 05.3	2.421	+ 26 11 53	2.92	1.11
932	β Draconis . .	3–2	27 50.1	+ 1.353	+ 52 23 12	2.81	1.64
933	***Groom. 2456*** .	6–7	28 30.2	− 4.623	+ 80 14 11	2.77	5.90
934	θ *Scorpii* . . .	3	29 03.4	+ 4.306	− 42 55 22	2.68	1.37
935	α Ophiuchi . .	2	17 29 35.8	+ 2.783	+ 12 38 40	− 2.89	1.02
936	ν¹ Draconis . .	4–5	29 54.7	1.179	+ 55 15 47	2.58	1.76
937	ξ Serpentis . .	4–3	31 00.1	3.431	− 15 19 30	2.50	1.04
938	μ *Ophiuchi* . .	5–4	31 35.6	+ 3.258	− 8 02 51	2.50	1.01
939	f **Draconis** . .	5–6	17 32 25.4	− 0.254	+ 68 12 29	2.28	2.69

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
W. R.	908		
B. H^{4} $G^{5.4.3}$ Rd. R. .	271		
A. E. C. B. N. $H^{4.2.2}$ G^{5-1}	909		
B. $H^{4.2}$ W. Rd. S^{2}. .	910		
H^{2} W. Rd. S^{2} . . .	911		
$H^{4.2}$	912	[A^{2}=6 mag.: $+0^{s}.2$: $+3''.4$	
C. N. $G^{5.3.2.1}$ W. O^{1} R.	913	A^{1}=4½ mag.: R	
C. B $G^{5.4.3.2.1}$ W. Rd. .	914	[a^{1}=3.1 to 3.9 mags. [$+0^{s}.34-1''.7$	
A^{1} E. C. B. N. $H^{4.2.1}$ G^{5-4}	915	Comp. 5½ mag.:	
C. B. $G^{5.2}$ W. R. S^{2} .	916	Comp. 8½ mag.: [$-0^{s}.0-19''.3$.	
A. C. B. $H^{4.3.2}$ $G^{5.2}$ W.	917		
H^{2} $G^{5.2}$ W. R. $S^{2.1}$.	918	W + H^{2} = μ.	
A. E. C. B. N. $H^{4.3.2.1}$ G^{5-1}	919		
O^{1} M. Gi	920		
O^{1} M. Gi	921		
C. $H^{4.2}$ G^{4} W. R. S. .	922		
A. N. $H^{4.2}$ $G^{5.4.3.2.1}$ W.	923	Var. = E.	
C. $G^{3.2}$ W. O^{1} M. R. .	924		
A. O^{1} M.	925		
E. H^{2} $G^{5.4.3.2.1}$ W. R. .	926		
$H^{4.2}$ G^{1} W. O^{1}. . .	927		
O^{1} M. Gi.	928		
B. G^{1} Bk. Rd. R. . .	929	Rd + G^{1} = χ.	
A. B. N. H^{4-1} $G^{5.4.2.1}$ W.	290		
A. H^{3} $G^{5.4.3.2.1}$ W. Rd. R.	291	Groom. 944.	
$H^{4.2}$ $G^{5.2.1}$ W. O^{1} . .	930	Sol. sys. moves towards	
H^{3} $G^{5.3.2.1}$ W. R. S^{2} .	931	this pt., Hersc. and Airy	
A. E. C. B. N. H^{4-1} G^{5-1}	932	* deep, dull orange.	
H^{3} Rd.	933		
O^{1} M.	934		
A. E. C. B. N. $H^{2.1}$ G^{5-1}	935	[$+4^{s}.4$: $-41''$; G^{3}.	
B. $G^{2.1}$ W. Rd. R. . .	936	ν^{2} Draconis = 4–5 mag.:	
B. $G^{5.4.3.2.1}$ W. O^{1} . .	937		
$H^{4.2}$ G^{3} R. . . .	938		
B. H^{4} $G^{5.3.1}$ W. Rd. R. .	939		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
940	κ *Scorpii*	3	17 34 32.0	+ 4.147	− 38 58 13	− 2.24	1.29
941	ο *Serpentis*	5–4	34 57.0	3.368	− 12 48 46	2.22	1.02
942	ι Herculis	3–4	36 13.5	1.703	+ 46 04 03	2.10	1.44
943	58 *Ophiuchi*	5	36 32.4	+ 3.593	− 21 37 34	2.11	1.08
944	ω **Draconis**	5	37 37.6	− 0.356	+ 68 48 40	1.62	2.77
945	β Ophiuchi	3	17 37 47.4	+ 2.960	+ 4 37 00	− 1.77	1.00
946	3 *Sagittarii*	5	17 40 19.3	3.772	− 27 47 09	1.75	1.13
307	***Rad. 1553**, S. P.*	6	5 40 35.1	6.747	+111 33 50	1.70	2.72
947	μ Herculis	3–4	17 41 57.5	2.346	+ 27 47 18	2.34	1.13
948	γ Ophiuchi	4–3	42 07.6	+ 3.005	+ 2 45 05	1.63	1.00
949	ψ¹ **Draconis**	4–5	17 43 59.1	− 1.080	+ 72 12 18	− 1.67	3.27
950	87 *Herculis*	6	44 09.4	+ 2.432	+ 25 39 49	1.18	1.11
951	30 *Draconis*	5–6	46 19.4	1.427	+ 50 48 30	1.03	1.58
952	*B. A. C.* 6062	5–6	48 20.2	1.952	+ 40 00 27	0.97	1.31
953	89 *Herculis*	6–5	50 46.8	2.420	+ 26 04 05	0.78	1.11
954	ξ Draconis	3–4	17 51 32.6	+ 1.041	+ 56 53 27	− 0.67	1.81
955	θ Herculis	4	52 18.5	2.055	+ 37 15 59	0.66	1.26
956	ν Ophiuchi	3–4	52 41.8	3.304	− 9 45 30	0.74	1.01
957	ξ Herculis	4–3	53 17.8	2.330	+ 29 15 39	0.62	1.15
958	γ Draconis	2–3	53 56.2	1.391	+ 51 30 09	0.62	1.61
959	67 Ophiuchi	4	17 54 53.1	+ 3.004	+ 2 56 16	− 0.51	1.00
960	**35 Draconis**	5	55 24.3	− 2.695	+ 76 58 38	0.24	4.38
961	68 *Ophiuchi*	5	55 55.1	+ 3.043	+ 1 18 32	0.31	1.00
962	τ *Ophiuchi*	5	56 50.4	3.270	− 8 10 35	0.26	1.01
963	γ² Sagittarii	3–4	17 58 25.2	3.851	− 30 25 27	0.36	1.16
964	p¹ Ophiuchi, 70	4–5	17 59 38.4	+ 3.030	+ 2 31 39	− 1.12	1.00
965	*B. A. C.* 6127	5	18 00 48.0	3.795	− 28 28 09	+ 0.02	1.14
328	**36 Camelop.**, S.P.	6–5	6 01 16.7	6.030	+114 44 21	+ 0.14	2.43
329	***Gr. 1004**, S. P.*	6–7	6 01 24.4	26.817	+ 93 14 15	− 0.20	17.71
966	72 Ophiuchi	3–4	18 01 53.8	2.843	+ 9 32 53	+ 0.21	1.01
967	ο Herculis	4–3	18 03 03.4	+ 2.339	+ 28 44 50	+ 0.28	1.14
333	**22 Camelop.**, S.P.	5–4	6 06 09.6	6.618	+110 38 31	0.66	2.84
968	μ¹ Sagittarii	4	18 06 53.2	3.587	− 21 05 16	0.59	1.07
969	A *Herculis*, 104	5	07 34.6	+ 2.261	+ 31 22 36	0.58	1.17
970	δ **Urs. Min.**	4–5	18 09 24.9	−19.435	+ 86 36 38	0.85	16.91

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
H^2 W. O^1 M.	940		
$G^{4.3.2.1}$ W. O^1 R.	941		
A.B.H^3 $G^{5.2.1}$ W.Rd.R.	942		
N. $H^{4.2}$ $G^{5.4.3.2.1}$ W. Rd.	943		
A. B. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$	944		
E.C. B. $H^{3.2}$ $G^{5.4.3.2.1}$ W.	945		
N. $H^{4.2}$ $G^{5.3.1}$ W. Rd.	946		
Rd. $G^{5.4.3}$	307		
A. E. C. B. N. H^{4-1} G^{5-2}	947	[$-2^s.0$: $-14''.0$: yl. bl. Comp. = 10 mag.: [Comp. doub.: Clark.	
B. H^3 $G^{3.2.1}$ W. R.	948		
A. B. N. $H^{4.3.2}$ $G^{5.4.3.2.1}$	949	[$+1^s.8$: $+30''$; W^2. $G^{5,3}$ = foll. star 5–6 mag.:	
H^2 $G^{5.3}$ R. S^2	950		
H^2 G^1 W. Bk. Rd. R.	951		
$H^{4.2}$ G^5 Rd. R. $S^{2.1}$	952		
$H^{4.2}$ $G^{5.4.2}$ W. R. S^2	953		
B. H^3 $G^{5.2.1}$ W. Rd. R.	954		
A. B. H^3 $G^{2.1}$ W. Bk.	955		
C. B. H^2 $G^{2.1}$ W.Bk. R.	956		
B. $G^{5.3.2}$ R.	957		
A. E. C. B. N. $H^{4.3.2.1}$ G.	958		
B. $G^{5.4.3.2}$ R.	959		
B. $H^{4.3.2}$ $G^{5.4.3.1}$ Rd. R.	960		
H^2 G^4 R.	961		
G^3 O. R.	962		
A. B. N. $H^{4.3.2}$ G^{5-2} W.	963	[$-44^s.8$: $-9'\ 33''$. γ^1: $5\frac{1}{2}$ mag.:	
C. H^3 $G^{5.3.1}$ W. R.	964	[$+0^s.30$: $-0''.1$. $G^5 = p^2$ 6 mag.: [per. about 80 years.	
$H^{4.2}$ $G^{5.3}$ W. O^1 R.	965		
B. R. Rd. H^4	328		
$G^{4.3.2.1}$ W. Rd.	329		
E. B. $G^{5.4.3.2.1}$ W. O^2	966		
A. B. $H^{4.2}$ G^5 W. Bk.	967		
A. B. N. $H^{4.3.2}$ $G^{5.3.1}$ W.	333		
A. E. C. B. N. H^{4-1} G.	968	[3.5, 9.5, 10 mags.: N = μ: triple	
H^3 G^5 W. R. $S^{2.1}$	969		
A. E. C. B. N. $H^{4.3.2.1}$ G.	970		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
971	η *Sagittarii* . .	4	18 09 50.7	+ 4.060	− 36 47 45	+0.81	1.25
972	*B. A. C.* 6194 .	6–5	10 51.4	3.760	− 27 04 57	0.89	1.12
973	*B. A. C.* 6203 .	6–5	12 04.0	1.857	+ 42 07 14	1.06	1.35
974	**36 Draconis** . .	5	13 14.0	0.344	+ 64 21 30	1.17	2.31
975	δ Sagittarii . .	3–4	13 37.9	3.841	− 29 52 32	1.17	1.15
976	η Serpentis . .	3	18 15 21.6	+ 3.102	− 2 55 39	+0.67	1.00
977	ε Sagittarii . .	3–2	16 32.3	3.983	− 34 26 20	1.30	1.21
978	*B. A. C.* 6241 .	5–6	17 20.9	2.499	+ 23 13 38	1.60	1.09
979	*B. A. C.* 6255 .	5	18 36.2	1.535	+ 49 03 48	1.60	1.53
980	109 Herculis . .	4	18 47.8	2.555	+ 21 43 05	1.34	1.08
981	λ Sagittarii . .	3–4	18 20 52.4	+ 3.703	− 25 29 03	+1.60	1.11
982	*b* Draconis . .	5	22 13.7	+ 0.873	+ 58 44 03	2.00	1.93
983	φ **Draconis** . .	4–5	22 24.4	− 0.853	+ 71 16 35	1.98	3.12
984	*Brad.* 2313. .	5	22 38.5	+ 3.420	− 14 38 18	1.95	1.03
985	χ **Draconis** . .	4–3	23 07.6	− 1.080	+ 72 40 57	1.64	3.36
986	*B. A. C.* 6300 .	6	18 24 49.9	+ 2.501	+ 23 47 25	+2.17	1.09
987	*B. A. C.* 6318 .	6	18 26 07.2	0.825	+ 59 28 22	2.30	1.97
350	**23 Camelop., S. P.**	5–6	6 26 35.1	10.415	+100 18 54	2.98	5.59
988	1 Aquilæ . . .	4–5	18 28 56.9	3.264	− 8 19 25	2.20	1.01
989	ζ Pavonis . . .	4	29 35.5	7.031	− 71 31 26	2.44	3.16
990	*d Draconis* . .	5–6	18 30 35.4	+ 1.032	+ 56 57 26	+2.61	1.83
991	α Lyræ . . .	1	33 02.7	+ 2.031	+ 38 40 38	3.15	1.28
992	σ Octantis. . .	6–5	33 30.7	+107.662	− 89 16 18	2.83	78.67
993	**Groom. 2655**.	6	35 18.1	− 2.855	+ 77 27 23	3.07	4.61
994	**Groom. 2640**.	6	35 51.5	+ 0.187	+ 65 23 08	3.15	2.42
995	2 *Aquilæ* . . .	5	18 35 58.6	+ 3.284	− 9 09 41	+3.12	1.01
996	φ *Sagittarii* . .	4–3	38 28.3	3.751	− 27 06 28	3.36	1.12
997	ε Lyræ, pr. . .	4–5	40 31.7	1.983	+ 39 33 01	3.60	1.30
998	5 Lyræ, med.. .	5–4	40 34.1	1.987	+ 39 29 34	3.60	1.30
999	110 Herculis . .	4	18 40 42.7	2.579	+ 20 26 13	3.17	1.07
364	**43 Camelop., S.P.**	5	6 41 18.0	+ 6.503	+110 58 48	+3.54	2.79
1000	*B. A. C.* 6404 .	6	18 42 32.5	1.916	+ 41 19 07	3.67	3.67
367	**24 Camelop., S.P.**	5–4	6 43 16.8	8.841	+102 52 44	3.75	4.49
1001	*B. A. C.* 6419 .	6–5	18 44 08.8	1.339	+ 52 51 43	3.82	1.66
1002	β Lyræ . . .	Var.	18 45 50.1	2.215	+ 33 13 47	3.97	1.20

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Authorities.	No.	Notes.	
$H^{4.3.2}$ $G^{5.2}$ W. O^1 M. .	971		
H^2 $G^{5.3}$ W. R. . .	972		
B. $G^{5.4}$ Rd. R. $S^{2.1}$.	973	Groom. 2533.	
B. H^3 $G^{5.4.3.1}$ Rd. R. .	974	Double: 4.5, 6.7 mags. [: 10″.6.	
C.N.$H^{4.3.2}$$G^{5.4.3.1}$W.$O^1$	975		
A. E. C. B. N. $H^{4.3.2}$ G.	976		
C. $G^{5.3.2.1}$ W. O^1 M .	977		
H^2 $G^{5.1}$ W. R. S^2 . .	978	Brad. 2308.	
H^2 G^3 R. $S^{2\,1}$ . . .	979	Groom. 2555.	
B. $H^{4.2}$ $G^{5.4}$ R. S^2 . .	980		
A. E. N. H^2 $G^{5.4.3.2.1}$ W.	981		
B. $H^{4.3.2}$ $G^{3.2.1}$ Rd. R.	982	[0″.6 apart.	
B. H^4 $G^{5.2}$ Rd. R. .	983	Doub. 4–5 and 6–7 mags.:	
$G^{4.3.1}$ W. R. . . .	984		
A. B. $H^{4.3.2}$ $G^{5.4.3}$ Rd. .	985		
H^2 $G^{5.4}$ R. S^2 . . .	986		
$H^{4.2}$ G^1 Rd. R. $S^{2.1}$.	987		
B. $H^{4.3}$$G^{5.4.3}$W. Rd. R.	350		
A. N. $H^{4.3.2}$ $G^{4.1}$ W. .	988		
A. $O^{2.1}$ M.	989		
$H^{3.2}$ G^1 Bk. Rd. $S^{2.1}$.	990	[−1ˢ.4: −40″.5, 1865.	
A^1E.C.B.N. $H^{4.2.1}$ G^{5-1}	991	Comp. = 11 mag.:	
A. E. N. Gi. $O^{2.1}$ M. .	992	[Test 3-4-in. obj., [another comp. 3″ to 4″.	
B. H^4 G^5 W. Rd. . .	993		
B. Rd.	994		
$H^{4.2}$ $G^{5.4.3}$ W. $O^{2.1}$ R. .	995		
$G^{5.4.3.2.1}$ W. O^1 M. Rd.	996	[=4 mag.: +0ˢ.2: +3″.2.	
B. $G^{5.3.1}$ W. Rd. R. .	997	G^3 = foll. star	
B. $G^{2.1}$ Rd. R. . . .	998	G^3 = foll. star	
B. $H^{4.3.2}$ W. R. S^2. .	999	[=4 mag.: +0ˢ.2: +2″.3.	
B. G^1 Bk. Rd. . .	364		
H^2 Rd. $S^{2.1}$ . . .	1000	[3 comps. 8, 8.5, 9.	
B. H^3 G^2 W. Rd. . .	367	[+1ˢ.83, −39″.2 G^5	
$H^{4.2}$ G^3 Rd. R. $S^{2.1}$.	1001	[2 max and min: β^2=8 mag. [per. = 12^d 21^h 47^m	
A. E. C. B. N. H^{4-1} G^{5-1}	1002	C=B′: 3.5—4.5	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
369	**51 Cephei**, S. P. .	5	6 46 15.6	+30.016	+ 92 46 34	+ 4.06	20.65
1003	σ Sagittarii . .	2–3	18 48 08.1	3.722	— 26 26 18	4.10	1.12
1004	ο Draconis . .	5–4	49 30.2	0.887	+ 59 14 53	4.32	1.96
1005	δ¹ *Lyræ* . . .	5–6	49 42.5	+ 2.095	+ 36 49 42	4.31	1.25
1006	**50 Draconis** . .	5–6	50 04.6	— 1.906	+ 75 17 52	4.42	3.94
1007	θ Serpentis, pr. .	4	18 50 30.1	+ 2.981	+ 4 03 18	+ 4.42	1.00
1008	13 Lyræ . . .	Var.	51 50.1	+ 1.826	+ 43 47 42	4.57	1.39
1009	***Rad. 4208*** . .	6–7	52 26.3	—18.595	+ 86 33 41	4.55	16.67
1010	ε Aquilæ . . .	4–3	54 24.1	+ 2.718	+ 14 54 46	4.60	1.03
1011	γ Lyræ . . .	3–4	54 38.5	2.244	+ 32 31 56	4.76	1.19
1012	ζ Sagittarii . .	3–4	18 55 17.7	+ 3.820	— 30 02 35	+ 4.78	1.16
1013	υ **Draconis** . .	5–6	55 48.2	— 0.716	+ 71 08 36	4.87	3.09
1014	*g Aquilæ* . . .	6	56 51.1	+ 3.165	— 3 51 51	4.95	1.00
1015	16 *Lyræ* . . .	5–6	18 58 11.0	1.695	+ 46 46 20	4.92	1.46
1016	ζ Aquilæ . . .	3	19 00 07.5	2.756	+ 13 41 36	5.10	1.03
1017	λ Aquilæ . . .	3–4	19 00 08.7	+ 3.186	— 5 03 14	+ 5.10	1.00
1018	π Sagittarii . .	3	02 55.5	3.570	— 21 12 19	5.39	1.07
1019	ι Lyræ . . .	5	03 11.9	2.141	+ 35 55 13	5.45	1.23
1020	*B. A. C.* 6561 .	6	19 05 35.9	3.589	— 21 50 54	5.59	1.08
385	**25 Camelop.**, S.P.	5	7 06 49.6	13.030	+ 97 22 14	5.80	7.78
1021	19 *Lyræ* . . .	6	19 07 21.3	+ 2.300	+ 31 05 32	+ 5.79	1.17
1022	ψ *Sagittarii* . .	6–5	08 29.3	3.682	— 25 27 12	5.86	1.11
1023	*d* Sagittarii . .	5	10 54.4	3.513	— 19 09 23	6.09	1.06
1024	θ Lyræ . . .	4–5	12 20.7	2.082	+ 37 55 45	6.22	1.27
1025	ω Aquilæ . . .	6–5	12 25.0	2.814	+ 11 23 20	6.25	1.02
1026	δ **Draconis** . .	3	19 12 34.2	+ 0.031	+ 67 27 32	+ 6.31	2.61
1027	κ Cygni . . .	4–3	14 26.6	1.385	+ 53 09 23	6.50	1.67
1028	*d Aquilæ* . . .	6	14 39.6	3.099	— 1 06 18	6.26	1.00
1029	*B. A. C.* 6626 .	6	15 33.7	+ 1.598	+ 49 21 22	6.47	1.53
1030	τ **Draconis** . .	4–5	17 45.6	— 1.114	+ 73 08 30	6.78	3.45
1031	χ¹ *Sagittarii* . .	5–6	19 18 16.6	+ 3.656	— 24 43 50	+ 6.65	1.10
395	**P. VII, 67**, S.P.	5–6	7 18 54.5	6.303	+111 18 06	6.81	2.76
1032	*b* Aquilæ . . .	5–6	19 19 29.2	2.861	+ 11 42 00	7.51	1.02
1033	δ Aquilæ . . .	3–4	19 42.0	3.025	+ 2 53 11	6.91	1.00
1034	4 *Cygni* . . .	5–6	19 22 00.6	2.159	+ 36 05 16	7.04	1.24

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Authorities.	No.	Notes.	
A.E.C.B.N.$H^{4.3.2.1}G^{5-1}$	369		
A.C.B.N.$H^{4.3.2}G^{5-1}$ W.	1003	[$-1^s.1:+29''.0$: Rd.	
B. H^3 $G^{5.3}$ Rd. R. . .	1004	o^1 same mag.:	
$H^{4.2}$ G^4 R. $S^{2.1}$ . . .	1005	δ^2, $\delta^1=4$ and 5 mag.: or. bl.	
A.$H^{4.3.2}G^{5.4.3}$W.Rd.R.	1006	[$+1^s.4:-5''.6$.	
B. N. H^3 $G^{3.2.1}$ W. R. .	1007	$\theta^2=4$–3 mag.:	
B. $H^{4.2}$ $G^{5.4.3}$ Rd. R. S^2.	1008	B = R Lyræ, mag. 4–5.	
W. Rd.	1009		
E. B. $H^{4.3.2}$ G^{5-1} W. O^2	1010		
A. C. B. H^3 $G^{5.2}$ W. R.	1011		
C. N. $G^{3.1}$ W. O^1 M. R.	1012		
B. $G^{5.3.2.1}$ W. Rd. R. .	1013		
$H^{4.2}$ G^4 W. R. . . .	1014		
$H^{3.2}$ Rd. R. $S^{2.1}$ . .	1015		
A.E.C.B.N.$H^{4.3.2.1}G^{5-1}$	1016		
C. B. $G^{5.2}$ R. . . .	1017		
C. B. N. $H^{4.3.2}$ G^{5-1} W.	1018		
A. B. H^3 $G^{5.4}$ W. R. S^2	1019		
$H^{4.2}$ W. R	1020		
A. $H^{2.1}$ $G^{5.4.3.1}$ W. Rd.	385		
$G^{5.4}$ R. $S^{2.1}$ . . .	1021		
N. $H^{4.2}$ $G^{5.4.3.2}$ W. $O^{2.1}$	1022		
A. N. $H^{4.2}$ $G^{5.4.3.2.1}$ W.	1023		
A. B. H^2 $G^{5.3.2.1}$ W. R.	1024	Comp. 10 mag.: yl. bl.	
E.C.B.$H^{4.3.2.1}G^{5.4.3.2}$W.	1025		
A. C. B. N. $H^{4.3.2}$ G^{5-1}	1026		
B. $H^{4.3.2}$ G^{5-1} Rd. R. S^2	1027		
H^2 G^1 Bk. R. . . .	1028		
H^2 $G^{5.4}$ Rd. $S^{2.1}$ . .	1029	Groom. 2815.	
A. B. N. $H^{4.3}$ $G^{5.4.3.2}$ W.	1030		
N. $H^{4.2}$ $G^{5.4.3.1}$ W. Rd.	1031		
A. B. N. $H^{4.3}$ $G^{5.3.2.1}$ W.	395		
C. $G^{5.3.1}$ R. S^2 . . .	1032		
A. E. C. B. N. $H^{4.3.2.1}$.	1033		
$H^{4.2}$ G^4 R. $S^{2.1}$ . .	1034		

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			h. m. s.	s.	° ′ ″	″	
1035	α *Vulpeculæ* . .	4–5	19 23 55.2	+ 2.494	+ 24 25 58	+ 7.09	1.10
1056	β¹ Cygni . . .	3	26 05.0	2.421	+ 27 43 08	7.36	1.13
1037	ι Cygni . . .	5–6	26 48.4	1.514	+ 51 29 06	7.53	1.60
1038	μ *Aquilæ* . . .	5–4	28 28.2	+ 2.931	+ 7 08 09	7.41	1.01
1039	**Groom. 2900.**	6–7	28 37.8	— 3.512	+ 79 22 17	7.56	5.42
1040	h^2 Sagittarii . .	5–4	19 29 42.5	+ 3.658	— 25 08 11	+ 7.62	1.10
1041	κ Aquilæ . . .	5	30 42.3	3.229	— 7 16 56	7.73	1.01
1042	ε *Sagittæ* . . .	6	32 05.0	2.715	+ 16 12 20	7.85	1.04
1043	θ Cygni . . .	5–4	33 21.4	1.609	+ 49 57 18	8.17	1.55
1044	*B. A. C.* 6737. .	5–6	33 32.8	0.639	+ 63 10 42	7.94	2.22
1045	14 *Cygni* . . .	4–5	19 35 41.9	+ 1.954	+ 42 33 12	+ 8.15	1.36
1046	β Sagittæ . . .	4–5	35 53.0	2.695	+ 17 12 38	8.14	1.05
1047	*B. A. C.* 6755 .	5–6	38 40.9	+ 2.833	— 32 11 06	8.31	1.18
1048	λ **Urs. Min.** . .	6–7	38 56.5	—63.646	+ 88 57 22	8.41	54.90
1049	15 Cygni . . .	5–6	40 07.8	+ 2.163	+ 37 04 37	8.52	1.25
1050	γ Aquilæ . . .	3	19 40 47.5	+ 2.852	+ 10 20 01	+ 8.53	1.02
413	**B.A.C.2320**, S.P.	6–7	7 40 50.8	70.110	+ 91 01 43	8.54	55.71
1051	δ Cygni . . .	3	19 41 22.8	1.877	+ 44 51 02	8.58	1.41
1052	δ Sagittæ . . .	4	42 15.7	2.679	+ 18 15 05	8.69	1.05
1053	ζ *Sagittæ* . . .	5	43 52.4	2.669	+ 18 51 16	8.81	1.06
1054	α Aquilæ . . .	1–2	19 45 10.3	+ 2.928	+ 8 33 55	+ 9.25	1.01
417	**Gr. 1374**, S. P.	6–5	7 46 24.5	7.293	+105 46 45	9.01	3.68
1055	η Aquilæ . . .	Var.	19 46 36.9	3.058	+ 0 41 28	8.97	1.00
1056	ε Pavonis . . .	4	47 17.0	7.056	— 73 12 42	8.94	3.46
1057	ι *Sagittarii* . .	4–5	47 19.3	+ 4.147	— 42 10 09	9.10	1.35
1058	ε **Draconis** . .	4	19 48 33.1	— 0.177	+ 69 58 30	+ 9.19	2.92
421	***156 Camelop.***, *S. P.*	6	7 49 16.4	+15.167	+ 95 36 48	9.22	10.23
1059	β Aquilæ . . .	4	19 49 39.9	2.947	+ 6 07 13	8.74	1.01
1060	g *Sagittarii* . .	6–5	51 25.6	3.406	— 15 47 44	9.28	1.04
1061	ψ Cygni . . .	5	52 39.4	1.551	+ 52 08 02	9.41	1.63
1062	γ Sagittæ . . .	4–3	19 53 38.6	+ 2.667	+ 19 10 50	+ 9.58	1.06
1063	c Sagittarii . .	5–4	55 35.2	3.698	— 28 01 42	9.71	1.13
1064	*B. A. C.* 6882 .	5	56 52.4	2.544	+ 24 28 55	9.83	1.10
1065	τ Aquilæ . . .	6–5	19 58 31.4	2.933	+ 6 57 15	9.92	1.01
1066	e *Draconis* . .	6–5	20 00 15.4	0.648	+ 64 29 46	10.01	2.32

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Authorities.	No.	Notes.	
$H^{3.2}$ $G^{5.4.3.2}$ W. O^{2} R. .	1035	[$+2^{s}.2: +20''.1$ yl. and bl.	
A.C.B.$H^{4.3.2}$$G^{5.4.3.2.1}$W.	1036	$G^{5}=\beta^{2}$, 7 mag.:	
B. H^{3} $G^{5.3.1}$ W. Rd. R.	1037	$G^{5.3.1}$: $i=6$ mag.:	
H^{2} $G^{5.4.3.2.1}$ W. R.. .	1038	[$-2^{m}\ 9^{s}.6, -36'\ 18''.7$; [Rd $=\iota=4$ mag.	
B. $H^{4.3}$ G^{5} Rd. . .	1039		
E. C. B. $H^{3.2.1}$ G^{5-1} W.	1040	[$-39^{s}.7: +10'\ 10''.5$ $H^{4}=h^{1}$ Sagitt. $=6$ mag.:	
A. C. N. $H^{4.2}$ $G^{4.2}$ W.	1041	[$+6^{s}.2: +15''.4$: yl. bl.	
$H^{4.2}$ $G^{5.4}$ W. R. S^{2} .	1042	Comp. $=8$ mag.:	
B. $H^{3}$$G^{5.4.3.1}$W. Rd. R.	1043		
$H^{4.2}$ G^{5} W^{2} Rd. S^{2}. .	1044		
G^{3} W. Rd. R. $S^{2.1}$ . .	1045		
A. $H^{4.2}$ G^{3} W. R. S^{2} .	1046		
$H^{4.2}$ $G^{2.1}$ W. M . .	1047	Piaz. XIX, 243.	
A. E. C. B. N. H^{4-1} G^{5-1}	1048		
B. G^{3} W. R. . . .	1049		
A^{1} E.C. B.N. $H^{4.2.1}$$G^{5-1}$	1050	Comp. $=12$ mag.	
C. $H^{3.1}$ $G^{5.4.3}$ W. Rd. R.	413	[$-0^{s}.04: +1''.6$.	
A. C. B. $G^{5.4.3.2.1}$ W. Rd.	1051	Comp. $=9$ mag.:	
B. $H^{4.2}$ G^{2} Bk. R. S^{2} .	1052	[diff. with mod. aperture.	
$H^{4.3}$ G^{3} W. R. . .	1053	Comp. $=9$ mag.: [$-0^{s}.5: +5''.7$, wh. bl.	
A^{1} E. C. B. N. $H^{4.2}$$G^{5-1}$	1054		
A. B. $H^{4.3.2}$$G^{5-1}$W. Rd.	417		
B. $H^{4.2}$ $G^{4.3.2}$ R. . .	1055	Mag. 3.5 to 4.7, per. 7.18 d's.	
A. $O^{2.1}$ M.	1056		
H^{2} W. O^{1} M. . . .	1057		
A. B. N. $H^{4.2}$$G^{5.4.3.1}$ W.	1058	[$+0^{s}.0: -2''.6$ yl. bl. G^{4} 2d star $=9\frac{1}{2}$ mag.:	
$H^{2.1}$ G^{1} W. Rd. . .	421		
A^{1} E. C.B.N.$H^{4.2.1}$$G^{5-1}$	1059		
N. $H^{3}$$G^{4.3.2.1}$ W. Rd. R.	1060	[$+0^{s}.03: -4''.7$.	
B. $G^{5.4}$ Rd. R. . . .	1061	G^{5} 2d star $=7\frac{1}{2}$ mag.:	
A. B. $H^{3.2}$$G^{2}$W. Bk. R.	1062		
A. C. N. $H^{2}$$G^{5.4.3.2.1}$ W.	1063		
H^{2} G^{2} W. R. S^{2} . .	1064		
A. N. H^{3} $G^{4.1}$ W. R. .	1065		
$H^{4.2}$$G^{5.4.2}$ W^{2} Rd. R. S^{2}	1066	$H^{2}=\varepsilon$.	

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No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
432	**3 Urs. Maj., S. P.**	6	8 01 21.5	+ 6.054	+111 11 21	+10.13	2.77
1067	*B. A. C.* 6924 .	6	20 02 44.6	1.363	+ 56 00 35	10.34	1.79
436	**Gr. 1408, S. P.**	5	8 05 04.1	7.706	+103 53 39	10.41	4.16
1068	θ Aquilæ . . .	3–4	20 05 22.2	3.007	— 1 09 42	10.43	1.00
1069	20 *Vulpeculæ* . .	6	07 11.3	2.515	+ 26 08 09	10.56	1.11
1070	ρ *Aquilæ* . . .	5	20 08 57.3	+ 2.774	+ 14 50 54	+10.77	1.03
1071	o¹ Cygni, foll. . .	4–5	10 00.6	1.889	+ 46 23 34	10.77	1.45
1072	33 Cygni . . .	4–5	10 43.5	1.400	+ 56 12 58	10.88	1.80
1073	α¹ Capricorni . .	4	11 16.4	3.328	— 12 51 45	10,86	1.03
1074	α² Capricorni . .	3–4	11 40.4	+ 3.333	— 12 54 02	10.90	1.03
1075	***Groom. 3402*** .	Var.	20 11 50.8	—49.281	+ 88 46 52	+10.91	47.08
1076	24 Vulpeculæ . .	6	11 51.8	+ 2.566	+ 24 19 02	10.87	1.10
1077	κ **Cephei** . . .	4–5	12 44.6	— 1.916	+ 77 21 53	11.01	4.57
1078	β² Capricorni . .	3–4	14 32 9	+ 3.376	— 15 08 37	11.11	1.04
1079	*B. A. C.* 7008 .	6	16 05.2	2.172	+ 39 02 28	11.21	1.29
1080	α Pavonis . . .	2	20 16 33.1	+ 4.787	— 57 06 08	+11.16	1.84
1081	γ Cygni . . .	3–2	18 06.2	2.154	+ 39 53 20	11.36	1.30
1082	π Capricorni . .	5	20 20 44.3	3.440	— 18 35 16	11.54	1.05
449	***Gr. 1418, S. P.***	6	8 21 14.5	16.807	+ 94 32 31	11.59	12.63
1083	ρ Capricorni (pr,).	6	20 22 18.0	3.428	— 18 11 35	11.65	1.05
1084	41 *Cygni* . . .	4–5	20 24 41.8	+ 2.451	+ 29 59 07	+11.84	1.15
1085	ω² *Cygni* . . .	4.2	20 26 29.9	1.857	+ 48 33 58	11.96	1.51
456	**Gr. 1446, S. P.**	6–5	8 26 43.8	6.814	+105 54 43	11.95	3.65
1086	θ Cephei . . .	4	20 27 39.0	1.017	+ 62 35 28	12.04	2.17
1087	ε Delphini . .	4	27 43.2	2.867	+ 10 54 47	12.03	1.01
1088	α *Indi* . . .	3	20 29 28.4	+ 4.240	— 47 41 28	+12.23	1.49
1089	ζ *Delphini* . .	5–4	29 55.9	+ 2.806	+ 14 16 40	12.21	1.03
1090	**Groom. 3241.**	6–7	30 29.8	— 0.217	+ 72 08 31	12.22	3.24
1091	β Delphini . .	3–4	32 09.3	+ 2.812	+ 14 11 44	12.32	1.03
1092	**73 Draconis** . .	5–6	33 00.9	— 0.725	+ 74 33 37	12.40	3.76
1093	υ Capricorni . .	6–5	20 33 30.2	+ 3.431	— 18 32 34	+12.45	1.05
1094	κ Delphini . .	4–3	33 32.6	+ 2.913	+ 9 40 54	12.46	1.01
1095	α Delphini . .	4–3	34 17.8	+ 2.788	+ 15 30 26	12.54	1.04
1096	β Pavonis . . .	3	34 35.2	+ 5.480	— 66 36 52	12.58	2.52
1097	***75 Draconis*** . .	5–6	35 24.4	— 3.514	+ 81 01 41	12.57	6.41

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
A. N. H^{4} $G^{5.4.3}$ W. Rd.	432		
$H^{4.3}$ G^{1} W^{3} Rd. $S^{2.1}$.	1067		
B. H^{4} $G^{5.4}$ Rd. R. . .	436		
A. E. C. B. $H^{4.3}$ $G^{5.4.3.2.1}$	1068		
$H^{4.3}$ $G^{5.4}$ R. S^{3}. . .	1069		
$H^{4.3.2}$ $G^{5.3.2}$ W. R. S^{3}. .	1070		
A. B. $G^{5.4.3.1}$ W. Rd. R.	1071	O^{1} prec. = 5 mag.: [—$19^{s}.4$: +4′ 32^{s}:	
B. $G^{2.1}$ W. Rd. R. . .	1072	[✱ 7–8 mag.: +1″: —1′.5	
C. B. N. $H^{4.2.1}$ $G^{5.4.3.2.1}$	1073		
A.E.C.B. N.$H^{4.2.1}$ G^{5-1}	1074	Comp. = 16 mag.: 5″ Doubled by Alvan Clark.	
$G^{5.4.3}$ W. Rd. . . .	1075	G^{5} + W = 5 mag.	
B. G^{3} R.	1076		
A.B.N.$H^{4.3.2}$ $G^{5.4.3.1}$W.	1077	k^{2} = 8.5 mag.: [+$1^{s}.9$: —4″.6, yl. bl.	
C. B. N. $H^{4.3}$ $G^{5.4}$ W. .	1078	Comp. = 7 mag.: —$14^{s}.0$: — 10″.7; yl. bl.	
$H^{4.3}$ $G^{5.4.3}$ Rd. R. $S^{2.1}$.	1079	Groom. 3140.	
A. E. C. N. O^{1} M. Gi.	1080		
A. C. B. N. $H^{4.3.2}$ $G^{5.3}$	1081		
A. N. $H^{4.2.3}$ $G^{5.4.2.1}$ W.	1082		
H^{3} $G^{5.4.3.2}$ W. Rd. R .	449		
E. C. B. N. $H^{4.3.2.1}$ G^{5-1}	1083	Brad. 2627 = 7 mag.: [+$8^{s}.4$: —3′ 31″.	
$H^{4.3}$ $G^{5.3}$ W. R. S^{3} .	1084		
$G^{5.3}$ W. R. Rd. . .	1085		
B. H^{4} G^{5} Rd. . . .	456		
B. H^{3} $G^{5.4.2.1}$ Rd. R. S^{3}	1086		
A. E. B. N. $H^{4.3.2}$ G^{5-1}	1087		
O^{1} M. Gi.	1088		
$H^{4.3}$ $G^{3.2.1}$ W. R. S^{3} .	1089		
A. N. H^{3} $G^{5.4}$ W. R. .	1090		
B. $H^{4.3}$ $G^{2.1}$ W. Bk. R.	1091		
B. H^{4} $G^{5.4.2.1}$ W. Rd. .	1092		
B. $G^{5.3.2.1}$ W. O^{1} Rd. .	1093		
B. G^{4} R.	1094		
A. C. B. $H^{4.3.2}$ $G^{5.4.3.2.1}$	1095		
A. $O^{2.1}$ M.	1096		
$G^{5.4.3.1}$ Bk. Rd. R. .	1097	Brad. 2701 = [—1^{m} $22^{s}.2$ + 56″.4	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
1098	10 *Delphini* . .	6	20 35 53.2	+2.813	+ 14 10 28	+12.65	1.03
1099	***74 Draconis*** . .	6–7	36 02.5	—3.244	+ 80 41 17	12.85	6.18
1100	α Cygni . . .	2–1	37 30.7	+2.044	+ 44 52 11	12.71	1.41
1101	δ Delphini . .	4	20 38 05.4	2.800	+ 14 39 45	12.71	1.03
464	***Gr. 1463, S. P.***	6	8 38 34.2	9.196	+ 99 32 34	12.80	6.03
1102	ψ Capricorni . .	4–5	20 39 17.1	+3.562	— 25 41 00	+12.68	1.11
1103	30 *Vulpeculæ* . .	6–5	39 53.9	2.597	+ 24 51 34	12.71	1.10
1104	γ Delphini, foll. .	3–4	41 19.4	2.782	+ 15 42 38	12.78	1.04
1105	ε Aquarii . . .	4–3	41 26.9	3.250	— 9 54 58	12.96	1.02
1106	ε Cygni . . .	3–2	41 33.4	2.427	+ 33 32 24	13.27	1.20
1107	3 Aquarii . . .	4–5	20 41 40.1	+3.171	— 5 26 52	+12.97	1.01
1108	Groom. 3281 .	5–4	42 29.8	1.488	+ 57 10 02	12.81	1.84
1109	λ Cygni . . .	5–4	42 55.7	2.334	+ 36 03 06	13.09	1.24
1110	η Cephei . . .	4–3	42 57.0	1.231	+ 61 23 32	13.91	2.02
1111	μ Aquarii . . .	5–4	46 27.1	3.240	— 9 24 51	13.27	1.01
1112	19 *Capricorni* . .	6	20 48 17.9	+3.397	— 18 21 29	+13.42	1.05
1113	32 Vulpeculæ . .	5–6	49 39.2	+2.554	+ 27 37 14	13.53	1.13
1114	**76 Draconis** . .	6	50 50.7	—4.014	+ 82 06 16	13.62	7.28
1115	**T. Y. C.** 1879 .	6–5	20 52 46.4	—2.535	+ 80 07 13	13.70	5.83
475	ρ **Urs. Maj.**, S. P.	5	8 52 09.8	+5.499	+111 55 24	13.66	2.68
1116	ν Cygni . . .	4	20 52 53.2	+2.234	+ 40 43 29	+13.71	1.32
478	***Gr. 1480, S. P.***	6	8 53 58.1	9.416	+ 98 42 45	13.80	6.60
1117	*B. A. C.* 7294 .	6	20 54 49.1	1.919	+ 50 00 56	13.86	1.56
1118	f^1 *Cygni* . . .	5–6	55 54.8	2.032	+ 47 04 20	13.88	1.47
1119	η *Capricorni* . .	5–6	57 51.6	3.422	— 20 18 33	13.99	1.07
1120	θ Capricorni . .	4–5	20 59 29.0	+3.379	— 17 41 21	+14.07	1.05
483	σ^2 **Urs. Maj.**, S. P.	5	9 00 15.7	3.561	+112 23 59	14.25	2.62
1121	ξ Cygni . . .	4	21 00 44.8	2.178	+ 43 28 09	14.22	1.38
1122	61[1] Cygni . . .	5–6	01 44.5	2.683	+ 38 11 04	17.52	1.27
1123	ν Aquarii . . .	4–5	03 19.8	3.273	— 11 50 12	14.37	1.02
1124	γ *Equulei*. . .	5–4	21 04 45.0	+2.919	+ 9 40 08	+14.31	1.01
1125	3 *Piscis Aust*. .	6	06 28.2	+3.569	— 28 05 11	14.51	1.13
1126	**77 Draconis** . .	6	07 45.7	—1.104	+ 77 39 35	14.69	4.68
1127	ζ Cygni . . .	3	08 02.5	+2.549	+ 29 45 20	14.60	1.14
1128	Groom. 3415 .	6–5	08 52.6	+1.529	+ 59 30 50	14.70	1.97

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
H^{2} G^{4} R. S^{3} . . .	1098		
$H^{2.1}$ $G^{5.4.3}$ Rd. R. . .	1099		
A.E.C.B.N. $H^{4.2.1}$ G^{4-1}	1100		
B. $G^{5.2.1}$ R.	1101		
$G^{5.4.3.2}$ Rd.	464		
A. C. N. $G^{5.3.2}$ W. O^{1} .	1102		
H^{2} $G^{5.4}$ W. R. S^{3} . .	1103		
B. $G^{5.2}$ W. R. . . .	1104	G^{5} pr. star = 7 mag.: [$-0^{s}.9$: $+0''.8$.	
E. B. $G^{5.4.3.2.1}$ W. O^{2} .	1105		
A. C. B. $H^{4.3.2}$ $G^{5.4.3.2}$.	1106		
C. G^{1} Bk. R. . . .	1107		
B. Rd. R.	1108		
B. H^{3} $G^{5.4.3}$ W. R. S. .	1109		
B. $H^{4.3.2}$ $G^{5.4.3.1}$ W. Rd.	1110		
A.C.N. $H^{4.3}$ $G^{5.4.3.2.1}$ W.	1111		
N. H^{2} G^{3} W. O. R. .	1112		
E.C.B. H^{4-1} G^{5-1} W. O^{2}	1113		
B. $H^{4.3}$ G^{5-1} W. Rd. R.	1114		
A. B. N. H^{4-1} $G^{5.4.2.1}$ W.	1115	Brad. 2749: Groom. 3373.	
B. $G^{5.4}$ W. Rd. R. . .	475		
A.B.N. $H^{4.2}$ $G^{4.3.2}$ W. O^{1}	1116		
$G^{2.1}$ W. Rd. . . .	478	[G^{5} 72: observe 1st [2d = $+0^{s}.14$: $+2''.2$.	
$H^{4.2}$ G^{5} Rd. $S^{2.1}$ . .	1117	As one mass 6 mag.:	
$G^{5.4.2.1}$ W. O^{1} Rd. R. $S^{2.1}$	1118	Pr. star $-0^{s}.7$: $-25''$.	
N. $H^{4.2}$ $G^{5.3.2.1}$ W. O^{1} Rd.	1119		
E. N. H^{2} $G^{5.4.3.2.1}$ W. O^{1}	1120		
A.B.N. $H^{4.3.2}$ $G^{5.3.2.1}$ W.	483		
B. $G^{5.4.3.2.1}$ O^{1} Rd. R. S^{3}	1121		
A.E.C.B.N. $H^{4.3.2.1}$ G^{5-2}	1122	61^{2} Cygni = 6 mag.: [$+1^{s}.5$: $-8''.0$ G^{5}.	
B. N. H^{2} $G^{5.4.3.2.1}$ W. O^{1}	1123		
$H^{4.2}$ $G^{4.3}$ W. R. . .	1124	G^{5}: 6 Equulei = 6 mag.: [$+13^{s}.0$: $-5'$ $18''$.	
H^{2} $G^{2.1}$ W. Bk. . .	1125	[γ doub. 5.4 and 11: $2''.1$.	
B. H^{4} $G^{5.4}$ W. Rd. R. .	1126	Gr. 3416. R = τ Drac.	
A.E.C.B.N. $H^{4.3.2.1}$ G^{5-1}	1127		
B. G^{3} W. Rd. R. . .	1128	Doub.: 6 and 7 mags.: $1''1$.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
1129	α Equulei	4	21 10 04.5	+ 3.000	+ 4 46 22	+14.70	1.00
1130	τ Cygni	4	10 11.9	2.392	37 33 19	15.26	1.26
1131	σ Cygni	4–5	12 53.9	2.355	38 54 47	14.93	1.29
1132	α Cephei	3–2	15 50.1	1.437	+ 62 05 55	15.17	2.14
1133	ι Capricorni	4–5	15 50.6	3.348	— 17 19 25	15.13	1.05
1134	1 Pegasi	4–5	21 16 46.1	+ 2.772	+ 19 18 47	+15.23	1.06
1135	γ *Pavonis*	3–4	16 55.3	5.041	— 65 53 12	16.03	2.45
1136	6 *Cephei*	6–5	16 58.9	1.255	+ 64 23 03	15.19	2.31
1137	*Groom.* 3441	6–5	18 00.5	2.077	+ 48 53 45	15.25	1.52
1138	ζ Capricorni	4	21 20 06.0	3.435	— 22 54 32	15.37	1.09
501	**1 Draconis, S. P.**	4–5	9 20 36.8	+ 9.046	+ 98 10 00	+15.40	7.04
1139	*B. A. C.* 7455	5–6	21 21 06.2	2.194	+ 46 12 59	15.53	1.46
1140	*b Capricorni*	5–4	22 09.9	+ 3.433	— 22 18 26	15.47	1.08
1141	**B. A. C. 7504.**	6	21 22 23.0	—11.044	+ 86 33 33	15.50	16.66
504	*d* **Urs. Maj.**, S.P.	5–4	9 24 17.7	+ 5.408	+109 39 55	15.54	2.97
1142	*g* Cygni	5	21 25 12.3	+ 2.208	+ 46 02 01	+15.74	1.44
1143	β Aquarii	3	25 30.3	3.162	— 6 04 36	15.65	1.01
1144	**β^3 Cephei**	3	27 10.3	0.796	+ 70 03 21	15.75	2.93
1145	*B. A. C.* 7488	6–7	27 24.3	2.026	+ 51 41 13	15.82	1.61
1146	ρ *Cygni*	4–5	29 39.3	2.252	+ 45 05 01	15.80	1.42
1147	ξ Aquarii	5–4	21 31 37.8	+ 3.198	— 8 22 10	+15.96	1.01
1148	74 Cygni	5	21 32 20.4	2.401	+ 39 53 49	16.04	1.30
511	**Gr. 1564, S. P.**	5–6	9 32 23.2	5.235	+110 14 24	16.10	2.89
1149	λ^1 Octantis	5–6	21 33 09.3	9.836	— 83 14 46	16.00	11.76
512	***Gr. 1562, S. P.***	6	9 33 36.3	7.452	+100 20 14	16.10	5.57
1150	γ Capricorni	4–3	21 33 43.1	+ 3.332	—.17 10 52	+16.08	1.05
1151	13 Cephei	6–5	35 25.4	1.860	+ 56 58 09	16.17	1.84
1152	75 *Cygni*	6–5	35 38.3	2.348	+ 42 45 07	16.21	1.36
1153	κ *Capricorni*	5	37 14.1	3.357	— 19 23 24	16.22	1.06
1154	ε Pegasi	2–3	38 32.3	2.947	+ 9 20 53	16.35	1.01
1155	κ Pegasi	4	21 39 26.2	+ 2.712	+ 25 07 00	+16.41	1.10
1156	**11 Cephei**	5	40 14.1	0.903	+ 70 46 55	16.54	3.04
1157	λ Capricorni	5–6	40 20.7	3.235	— 11 53 46	16.43	1.02
1158	δ Capricorni	3–4	40 41.6	3.318	— 16 38 55	16.15	1.04
1159	π^2 Cygni	4–5	42 32.7	2.211	+ 48 46 40	16.54	1.52

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
B. G$^{5.4.3.2.1}$ W. R. . . .	1129		
A.C.B.H$^{4.2}$G$^{5.2.1}$ W.R.	1130		
C. H$^{4.2}$ G$^{5.3}$ W. Rd. R.	1131		
A. E. C. B. N. H$^{4.2}$ G$^{5-1}$	1132		
N. G$^{5.4.3.2.1}$ W. O^{1} M. .	1133		
A. B. N. H^{2} G^{4} W. R. .	1134	[— 1^{s}.9: + 23″.5, yl. bl. Comp. = 9 mag.:	
O$^{2.1}$ M.	1135		
G$^{5.3}$ Rd. R. S^{2}. . .	1136		
G^{3} W. Rd.	1137	[—1^{m} 40^{s}.2: — 1′ 50″. Gr. 3435 = 6.5 mag.:	
A. C. B. N. H^{2} G$^{5.2.1}$ W.	1138		
A.B. N. H$^{4.3.2.1}$ G$^{5-1}$ W.	501		
G^{4} Rd. R. S$^{2.1}$. . .	1139	Brad. 2792.	
N. H$^{4.2}$ G$^{5.4}$ W. R. .	1140		
C. G$^{5.4}$ W^{2} Rd. . .	1141	[W^{2} = 7.8 mag.:. Gr. 3548: Rd = 7½ mag.:	
A. B. N. H$^{4.2}$ G$^{5.4.3.1}$ W.	504		
B. G$^{4.3.1}$ Rd. R. . .	1142	[+5^{s}.2: —8″. G^{3} = g^{2} Cyg. = 6–7 mag.:	
A.E.C.B.N.H$^{4-1}$G$^{5.3.2.1}$	1143		
A. E. C. B. N. H$^{4-1}$ G$^{5-1}$	1144	[—2^{s}.40: —4″.3 G^{5}. N = β: β^{1} = 8 mag.:	
H^{2} G^{4} Rd. S$^{2.1}$ . .	1145	Groom. 3485.	
H^{4} G^{3} W. Rd. R. S$^{2.1}$.	1146		
A. N. H$^{4.2}$ G$^{5-1}$ W. Rd.	1147		
A.B. G$^{5.4.3.2.1}$ W. Rd.R.	1148	[+1^{s}.46: + 0″.9, M. λ^{2} = 8–9 mag.:	
B. H$^{4.3}$ Rd. . . .	511		
A. O^{1}	1149		
G^{5} W. Rd. . . .	512		
C. B. N. H$^{4.3.2}$ G$^{5-1}$ W.	1150		
B. G^{2} Rd. R. . . .	1151	[foll. * = 8.4: + 1^{s}.3 — 7″. Pr. * = 8.4 mag.:	
G$^{5.4.3}$ W. Rd. R. S$^{2.1}$.	1152	[0^{s}.8: + 18″.	
N. H$^{4.2}$ G$^{5.4.3.2.1}$ W. Rd.	1153		
A. E. C. B. N. H$^{4-1}$ G$^{5-1}$	1154	[—5^{s}.5: + 1′ 51″.2. Comp. = 9 mag.:	
B. G$^{4.3.1}$ Bk. R. . .	1155	[—0^{s}.8: + 7″.	
A. B. N. H$^{4.2}$ G$^{5.4.3.1}$ W.	1156	Rd 5345 = 8–4 mag.: Rd 5347 = 8–4 mag.:	
B. G$^{4.3.1}$ W. Rd. R. .	1157	[+23^{s}.2: — 5′ 24″.	
C. B. N. H$^{4.3.2}$ G$^{5-1}$ W.	1158	"The Garnet star of Her- [schel."	
A. B. H$^{4.2}$ G$^{3.1}$ Rd. R.	1159		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
1160	14 *Pegasi* . . .	5	21 44 45.5	+ 2.645	+ 29 38 20	+16.65	1.15
1161	γ *Gruis* . . .	2–3	46 58.1	3.648	— 37 54 23	16.78	1.27
1162	μ Capricorni . .	5	47 01.5	3.277	— 14 05 33	16.77	1.03
1163	16 Pegasi . . .	5–6	21 47 49.8	2.728	+ 25 23 03	16.80	1.11
524	**Gr. 1586, S. P.**	6–7	9 48 04.7	5.494	106 34 28	16.86	3.51
1164	*B. A. C.* 7636 .	6	21 49 14.5	+ 2.017	+ 55 40 12	+16.83	1.77
1165	μ *Cephei* . . .	5–6	51 01.3	2.010	+ 56 04 01	16.95	1.79
1166	**A Draconis (79)**	6–7	51 26.0	0.731	+ 73 09 30	17.01	3.45
1167	η *Piscis Aus.* . .	5–6	54 13.8	3.457	— 29 00 18	17.10	1.14
1168	20 Pegasi . . .	6–5	55 29.2	2.923	+ 12 34 09	17.11	1.02
1169	o *Aquarii* . . .	5–4	21 57 22.0	+ 3.106	— 2 42 36	+17.25	1.00
1170	α Aquarii . . .	3	21 59 52.6	3.083	— 0 52 41	17.35	1.00
1171	ι Aquarii . . .	4	22 00 13.6	3.246	— 14 25 37	17.31	1.03
1172	α Gruis . . .	2	00 58.9	3.808	— 47 31 02	17.23	1.48
1173	20 Cephei . . .	6	01 30.8	1.820	+ 62 13 29	17.45	2.15
1174	ι Pegasi . . .	4	22 01 39.4	+ 2.789	+ 24 47 02	+17.47	1.10
1175	15 *Piscis Aus.* . .	5–6	03 24.2	3.541	— 33 06 45	17.52	1.19
1176	π^1 Pegasi . . .	5	04 09.9	2.653	+ 32 36 39	17.48	1.19
1177	θ Pegasi . . .	3–4	04 24.9	3.027	+ 5 37 53	17.59	1.01
1178	π^2 Pegasi . . .	4	04 52.8	2.660	+ 32 36 51	17.57	1.19
1179	ζ Cephei . . .	4–3	22 06 41.7	+ 2.076	+ 57 38 04	+17.64	1.87
1180	**24 Cephei** . . .	5–4	07 35.6	1.166	+ 71 46 30	17.68	3.20
1181	*B. A. C.* 7765 .	5	08 56.6	2.568	+ 39 08 40	17.74	1.29
1182	ν Octantis . .	6	22 09 18.7	13.326	— 86 33 01	17.85	16.62
537	**32 Urs. Maj., S. P.**	6	10 09 40.3	4.426	+114 19 07	17.81	2.43
1183	α *Tucanæ* . . .	4–3	22 10 36.9	+ 4.163	— 60 49 56	+17.73	2.05
1184	θ Aquarii . . .	4–5	22 10 45.9	3.169	— 8 21 20	17.79	1.01
541	***B.A.C.3495, S.P.***	5–6	10 12 46.8	9.664	+ 95 09 53	17.95	11.11
1185	45 *Aquarii* . . .	6	22 12 50.4	3.226	— 13 52 49	17.89	1.03
1186	ρ *Aquarii* . . .	5–6	14 08.8	3.161	— 8 23 53	17.95	1.01
1187	γ Aquarii . . .	4–3	22 15 42.9	+ 3.100	— 1 57 59	+18.03	1.00
544	**30 Urs. Maj., S. P.**	5	10 15 49.6	4.395	+113 51 09	18.03	2.47
1188	31 Pegasi . . .	5–4	22 15 51.4	2.950	+ 11 37 34	18.02	1.02
545	**30 Camel., S. P.** .	5	10 16 57.4	7.845	+ 96 51 26	18.03	8.38
1189	49 *Aquarii* . . .	6	22 17 06.2	3.358	— 25 20 37	18.05	1.11

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
$H^{4.2}$ G^3 R. S^3 . . .	1160		
$W^{2.1}$ O^1 M. . . .	1161		
A.N.$H^{4.2}$$G^{5.4.3.2.1}$W.$O^1$	1162		
A.E.C.B.$H^{4.3}$$G^{4.3.2}$W.	1163		
B. H^4 $G^{5.4.2}$ W. Rd. .	524		
$H^{4.2}$ G^1 Rd. R. $S^{2.1}$.	1164		
$H^{4.2}$$G^{2.1}$$W^{2.1}$Rd.R.$S^{2.1}$	1165		
A.N.$H^{4.3}$$G^{5.4.2}$W.Rd.	1166	G^5 = 79 Draconis.	
$H^{4.3.2}$ $G^{5.4.3}$ W. O^1 . .	1167		
B. $G^{5.2}$ R. S^3 . . .	1168		
$H^{4.2}$ $G^{4.3}$ W. R. . .	1169		
A^1 E.C.B.N.$H^{4.2.1}$$G^{5-1}$	1170		
C. B. N. $G^{5.4.3.2.1}$W.O^1	1171		
A. E. C. N. W. O^1 M.	1172		
B. $G^{5.4}$ Rd. R.. . .	1173		
B. $H^{4.3.2}$$G^{5.3.2}$W. R. S^3	1174	H^2 = *i*.	
G^4 W.	1175		
B. $G^{5.2.1}$ W. R. . .	1176		
B. $H^{4.2}$ $G^{2.1}$ Bk. R. .	1177		
A. B. $G^{5.1}$ W. R. S^3 .	1178		
C.B.$H^{4.3.2}$$G^{5.3.2.1}$W.Rd.	1179		
B. $H^{4.3}$ G^{5-2} W. Rd. R.	1180		
$H^{4.3.2}$ G^5 W. Rd. R. $S^{2.1}$	1181	[O^1 = C Octantis. Piazzi XXII^h 36:	
A. $O^{2.1}$ M.. . . .	1182		
A. N. H^3 $G^{5.4.2.1}$ W. R.	537		
O^1 M. Gi.	1183		
A. E. C. B. N. $H^{4.3.2.1}$ G.	1184		
$G^{5.3.2.1}$ W. Rd. . .	541		
N. $G^{5.3}$ W. O^1 R.. .	1185		
N. $H^{4.2}$ $G^{5.4.2.1}$ W. R. .	1186		
A. E. C. B. $H^{4.3.2}$$G^{5-1}$.	1187		
B. $G^{5.4.3}$ W. Rd. R. .	544		
B. $G^{5.3}$ W. R.. . . .	1188		
B. $H^{3.1}$ $G^{5.2.1}$W. Rd. R.	545		
G^4 W. R.	1189		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
1190	*B. A. C.* 7803 .	6	22 17 07.0	+2.529	+ 43 09 58	+18.04	1.37
1191	β Lacertæ . . .	4–5	19 02.3	2.350	+ 51 39 11	17.94	1.61
1192	π Aquarii . . .	5–4	19 24.3	3.065	+ 0 47 39	18.15	1.00
1193	*B. A. C.* 7824 .	6–7	20 27.0	2.383	+ 50 40 16	18.18	1.58
1194	*B. A. C.* 7825 .	7	20 46.1	2.406	+ 49 49 03	18.19	1.55
1195	***B. A. C. 7851*** .	5–6	22 22 19.3	−3.939	+ 85 31 43	+18.31	12.83
1196	ζ *Aquarii* . . .	3–4	22 54.6	+3.089	− 0 36 29	18.32	1.00
1197	σ Aquarii . . .	5–4	24 33.6	3.179	− 11 15 58	18.31	1.02
1198	δ Cephei . . .	4	24 54.1	2.216	+ 57 49 35	18.32	1.88
1199	β *Piscis Aus.* . .	4	22 24 58.0	3.424	− 32 56 09	18.32	1.19
553	**9 Draconis, S. P.**	5–4	10 25 17.9	+5.275	+103 41 43	+18.38	4.22
1200	α Lacertæ . . .	4	22 26 33.1	2.460	+ 49 41 28	18.40	1.55
1201	υ *Aquarii* . . .	6–5	28 23.5	3.292	− 21 17 48	18.38	1.07
1202	η Aquarii . . .	4–3	29 26.8	3.084	− 0 42 36	18.45	1.00
1203	**226 Cephei** . .	5–6	30 15.1	1.079	+ 75 38 02	18.53	4.03
1204	κ *Aquarii* . . .	5–6	22 31 48.1	+3.110	− 4 49 15	+18.47	1.00
1205	**31 Cephei** . .	5	32 55.7	1.488	+ 73 02 47	18.64	3.43
1206	10 Lacertæ . . .	5	34 06.1	2.686	+ 38 27 07	18.66	1.28
1207	β Octantis . . .	5–4	34 14.0	6.512	− 81 59 01	18.67	7.17
1208	ε *Piscis Aus.* . .	4	34 17.7	3.328	− 27 38 35	18.66	1.13
1209	30 Cephei . . .	5–6	22 34 34.3	+2.114	+ 62 59 12	+18.63	2.20
560	**35 Urs. Maj., S. P.**	5	10 34 49.3	4.386	+110 13 46	18.68	2.89
1210	11 *Lacertæ* . . .	4–5	22 35 28.2	2.615	+ 43 40 34	18.69	1.38
1211	ζ Pegasi . . .	3–4	35 43.6	2.991	+ 10 13 53	18.70	1.02
1212	β *Gruis* . . .	2–3	35 47.6	3.610	− 47 29 07	18.72	1.49
1213	η Pegasi . . .	3	22 37 36.7	+2.808	+ 29 37 12	+18.76	1.15
1214	13 Lacertæ . . .	6	38 57.8	2.666	+ 41 12 56	18.83	1.33
1215	λ Pegasi . . .	4–5	40 59.5	2.883	+ 22 57 39	18.87	1.09
1216	τ Aquarii . . .	4	43 30.2	3.180	− 14 11 58	18.90	1.03
1217	μ Pegasi . . .	4	44 27.0	2.878	+ 23 59 40	18.95	1.09
1218	ι **Cephei** . .	4–3	22 45 35.2	+2.121	+ 65 35 44	+18.87	2.42
1219	λ Aquarii . . .	4	46 36.9	+3.133	− 8 11 29	19.07	1.01
1220	***34 Cephei*** . . .	5	47 53.5	−0.083	+ 82 32 37	19.12	7.71
1221	δ Aquarii . . .	3	48 32.7	+3.186	− 16 25 54	19.06	1.04
1222	ρ *Pegasi* . . .	5–6	22 49 23.3	+3.022	+ 8 12 10	19.16	1.01

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
$H^{3.2}$ $G^{4.3}$ W. Rd. $S^{2.1}$.	1190	Gr. 3751 : Rd = 7.4 mag.	
B. $H^{4.3.2}$ $G^{4.3.1}$ W. Rd. S^{2}	1191	β = 3 Lacertæ.	
A. N. $H^{4.2}$ $G^{4.3.1}$ W. R.	1192		
Rd. $S^{2.1}$	1193		
Rd. $S^{2.1}$	1194	[Bk = 483 : 32 Cephei. [$+25^{s}$: $+6' 52''$.	
H^{3} $G^{5.4.3.2}$ W. Rd. R. .	1195	Br. 2997 = 6–7 mag. :	
$H^{4.2}$ $G^{4.3.1}$ W. O^{1} Rd. .	1196	{One mass : W = 4.7 and {5.0 mags. : $+0^{s}.1$: $-4''.3$.	
A. N. H^{3} G^{5-1} W. O^{1} .	1197	[δ^{1} = 7 mag. : $+0^{s}.8$: $-40''$, [per. 5^{d} 8^{h} 47^{m} 40^{s}.	
B. $G^{5.4.3.1}$ Rd. R. . .	1198	G^{4} = var. 3.7 to 4.9 mag. :	
$H^{4.2}$ $G^{5.4.3.2.1}$ W. O^{1} M.	1199	Comp. = 8 mag. : [$+0^{s}.3$: $-28''.7$ (1870.)	
A. B. N. $H^{4.2}$ $G^{5.4}$ W. Bk.	553		
A. B. $H^{4.3.2}$ $G^{5.2.1}$ W. Rd.	1200	A = 7 Lacertæ.	
G^{3} R.	1201		
A. E. C. B. N. H^{4-1} G^{5-1}	1202		
A. N. $H^{4.3.2}$ $G^{5.4}$ W. Rd.	1203	Groom. 3834.	
N. H^{2} $G^{4.3.2}$ W. O^{1} Rd.	1204		
B. H^{4} $G^{5.4.3.1}$ W. Rd. R.	1205		
A. B. $G^{5.4}$ W. Rd. R. .	1206		
A. O^{1} M.	1207		
$H^{4.3.2}$ $G^{2.1}$ W. O^{1} Bk. .	1208		
B. $G^{5.3.1}$ W. Rd. R. .	1209		
B. $H^{4.3}$ $G^{5.1}$ W. Rd. R.	560		
$G^{5.4.3}$ Rd. R. $S^{2.1}$ . .	1210		
A. E. C. B. N. H^{4-1} G^{5-1}	1211		
O^{1} M.	1212		
C. B. $H^{4.3.2}$ $G^{5.2.1}$ $W^{2.1}$ R.	1213		
B. $H^{4.3.2}$ G^{4} W. Rd. R.	1214		
A. B. $H^{4.3}$ $G^{5.3}$ W. R. S^{2}	1215		
B. $G^{5.4.3.2.1}$ W. O^{2} Rd. .	1216	R + $G^{5.4.2}$ = r^{s}.	
B. $H^{4.2}$ $G^{5.4.3.2.1}$ W^{2} Rd.	1217		
A. B. N. $H^{4.3.2}$ G^{5-1} W.	1218		
A. E. C. B. N. $H^{4.2}$ G^{5-1}	1219		
$H^{3.1}$ $G^{5.4.1}$ W. Rd. R. .	1220	Brad. 3038 : G^{5}.	
C. B. $H^{4.3.2}$ $G^{5.3.2.1}$ W. O^{1}	1221		
G^{4} R.	1222		

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
1223	δ *Piscis Aus.*	5	22 49 34.7	+3.339	− 33 09 09	+19.21	1.19
578	**Gr. 1706, S. P.**	6–5	10 50 43.3	4.992	+101 36 51	19.19	4.97
1224	α Piscis Aus.	1–2	22 51 17.7	3.326	− 30 13 53	18.99	1.16
1225	51 *Pegasi*	6–5	51 49.1	2.948	+ 20 09 08	19.24	1.07
1226	52 *Pegasi*	6	53 26.6	3.001	+ 11 06 53	19.20	1.02
1227	3 *Piscium*	6	22 54 43.9	+3.072	− 0 25 51	+19.27	1.00
1228	***36 Cephei***	5–4	55 17.1	−0.243	+ 83 43 50	19.25	9.16
1229	ο Andromedæ.	4–3	56 37.8	+2.749	+ 41 42 28	19.26	1.34
1230	β Pegasi	Var.	58 11.9	2.901	+ 27 27 34	19.48	1.13
1231	α Pegasi	2	22 59 02.0	2.985	+ 14 35 12	19.30	1.03
1232	55 *Pegasi*	5	23 01 12.6	+3.023	+ 8 47 18	+19.37	1.01
1233	c^2 Aquarii	4	03 18.8	3.206	− 21 47 46	19.46	1.08
1234	π **Cephei**	5	04 14.5	1.888	+ 74 45 57	19.41	3.81
1235	59 *Pegasi*	5	05 55.8	3.027	+ 8 05 44	19.49	1.01
1236	Brad. 3077	6	23 07 44.8	2.861	+ 56 32 00	19.80	1.81
590	***Gr. 1747, S. P.***	7–6	11 07 39.9	+4.623	+101 03 52	+19.54	5.21
1237	φ Aquarii	4–5	23 08 22.0	3.109	− 6 40 06	19.35	1.01
1238	ψ^1 *Aquarii*	5–4	09 52.0	3.147	− 9 42 47	19.57	1.01
1239	γ Piscium	4	11 12.6	3.108	+ 2 39 14	19.61	1.00
1240	ψ^3 *Aquarii*	5	12 58.8	3.124	− 10 14 22	19.63	1.02
1241	ο **Cephei**	6–5	23 13 54.4	+2.442	+ 67 28 57	+19.67	2.61
1242	τ Pegasi	5–4	23 14 56.7	2.963	+ 23 06 39	19.65	1.09
599	**Gr. 1771, S. P.**	6	11 16 00.7	3.603	+115 02 25	19.66	2.36
1243	b^1 *Aquarii*	5–4	23 16 55.8	3.157	− 20 43 42	19.60	1.07
1244	υ Pegasi	5–4	19 38.4	2.987	+ 22 46 16	19.78	1.08
1245	4 Cassiopeiæ	6	23 19 43.9	+2.639	+ 61 39 05	+19.72	2.11
1246	κ Piscium	5–4	21 02.2	3.074	+ 0 37 34	19.66	1.00
1247	θ Piscium	4–5	22 08.1	3.041	+ 5 44 50	19.72	1.01
1248	70 Pegasi	5	23 23 20.3	3.028	+ 12 07 34	19.83	1.02
606	***202 Camelop.***	6	11 23 42.4	4.480	+ 98 14 24	19.78	6.98
609	λ **Draconis, S. P.**	3–4	11 24 33.9	+3.626	+110 02 04	+19.84	2.92
1249	*B. A. C.* 8188	5	23 24 43.3	+2.741	+ 57 54 54	19.81	1.88
1250	b^4 *Aquarii*	5–4	27 15.5	+3.145	− 21 33 00	19.86	1.08
1251	**39 Cephei**	5–6	27 50.2	−0.059	+ 86 40 23	19.87	17.23
1252	72 Pegasi	6	23 28 14.9	+2.964	+ 30 41 26	19.85	1.16

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
$G^{2.1}$ W. M. . . .	1223		
A. B. H^{4} G^{5} W. Rd. .	578		
A^{1} E.C.B.N. $H^{4.2.1}$ G^{5-1}	1224		
$G^{5.4}$ R. S^{2}. . . .	1225		
G^{4} W. R. S^{2} . . .	1226		
N. G^{1} Bk. Rd. R. . .	1227		
H^{3} $G^{5.4}$ W. Rd. R. .	1228	Groom. 3970.	
A.B.$H^{4.2}$ $G^{5.3.1}$Rd.R.S^{2}	1229		
C. B. $G^{5.4.3.2.1}$W. R. S^{2}.	1230	Mag.: 2.3.	
A^{1} E. C. B. N. H^{4-1} G^{5-1}	1231		
$H^{4.2}$ G^{3} R.	1232		
C. B. $H^{4.2}$ G^{3} W. R. .	1233		
B. H^{4} $G^{5.4.3.1}$ W. Rd. R.	1234		
$H^{3.2}$ G^{4} W. R. . . .	1235		
B. G^{5} Rd. R. S^{2} . .	1236		
Rd.	590		
A. N. $H^{4.2}$ $G^{4.2.1}$ W. O^{1}	1237	[—$2^{s}.5$: +31″.8: or. bl.	
N. $G^{5.4.3.1}$ $W^{2.1}$ R. . .	1238	Comp. = 9 mag.:	
E. C. B. N. $H^{4.3.2.1}$ G^{5-1}	1239		
N. $H^{4.3.2}$ $G^{5.4.3.2.1}$ W. O^{1}	1240		
A. N. $H^{4.3}$ G^{5-1} W. Rd.	1241		
A. B. $H^{4.2}$ G^{5-1} W. Rd.	1242		
B. H^{4} $G^{5.4}$ W. Rd. .	599		
$H^{4.2}$ $G^{4.3}$ W. R. . .	1243		
C. B. $H^{4.2}$ $G^{5.3}$ W. R. S^{2}	1244		
B. $G^{5.3.2.1}$ W. Rd. R. .	1245		
E. C. B. N. $H^{3.1}$ G^{5-1} .	1246		
A. N. $H^{4.2}$ $G^{4.2.1}$ W. R.	1247		
B. $G^{5.3}$ R.	1248		
$H^{3.1}$ G^{5} W. Rd. . .	606		
A.E.C.B.N.$H^{4.3.2}$ $G^{5.4.2.1}$	609	[=7.8 mag.: —$9^{s}.4$: —2″.	
$G^{4.2.1}$ Rd. R. $S^{2.1}$. . .	1249	Piaz. $XXIII^{h}$ 100:	
$H^{4.2}$ G^{3} W. R. . . .	1250	H^{3} = b^{3} Aquarii.	
C.$H^{2.1}$ $G^{5.4.2.1}$ W^{3}Rd. R.	1251	C = B. A. C. 8213:	
B. G^{4} R.	1252	[=Brad. 3147, G^{5}.	

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

No.	Star.	Mag.	Right Ascen., 1885.0.	Annual Var.	Declination, 1885.0.	Annual Var.	Sec. δ
			h. m. s.	s.	° ′ ″	″	
1253	15 *Andromedæ* . .	5–6	23 29 00.0	+2.922	+ 39 36 10	+19.82	1.30
1254	16 *Piscium* . .	6	30 31.2	3.060	+ 1 27 50	19.93	1.00
1255	λ Andromedæ .	4	31 56.3	2.920	+ 45 50 05	19.45	1.44
1256	ι Andromedæ .	4	32 29.7	2.924	+ 42 37 54	19.93	1.36
1257	ι Piscium. . .	4–5	34 02.1	3.084	+ 5 00 11	19.47	1.00
1258	γ **Cephei** . . .	3–4	23 34 37.9	+2.411	+ 76 59 26	+20.07	4.50
1259	κ Andromedæ .	4	23 34 44.7	2.938	+ 43 41 50	19.91	1.38
615	**3 Draconis**, S. P.	5–6	11 36 03.1	3.402	+112 37 07	19.90	2.60
1260	λ *Piscium* . .	5	23 36 10.7	3.060	+ 1 08 43	19.76	1.00
1261	ω^2 Aquarii . . .	5–4	36 45.5	3.114	+ 15 12 10	19.90	1.04
1262	78 *Pegasi* . . .	5	23 38 12.6	+3.013	+ 28 43 30	+19.98	1.14
1263	i^1 Aquarii . . .	5	38 14.2	3.116	— 18 54 55	19.96	1.06
1264	ψ *Andromedæ* . .	5	40 20.2	2.955	+ 45 46 55	19.96	1.46
1265	20 *Piscium* . . .	6	42 01.8	3.084	— 3 24 03	19.99	1.00
1266	**41 Cephei** . . .	6	42 24.9	2.824	+ 67 10 04	19.98	2.58
1267	δ Sculptoris . .	4–5	23 42 56.1	+3.136	— 28 45 58	+19.90	1.14
1268	*B. A. C.* 8289 .	6–7	23 44 37.4	2.948	+ 50 58 59	19.97	1.59
622	***Gr. 1828**, S. P.*	7	11 45 08.4	3.303	+110 31 31	20.01	2.85
1269	γ^1 Octantis . .	5–6	23 45 18.9	3.704	— 82 39 29	19.99	7.83
1270	φ Pegasi . . .	6–5	46 38.3	3.046	+ 18 28 54	20.00	1.05
1271	ρ Cassiopeiæ . .	5	23 48 38.5	+2.969	+ 56 51 33	+20.02	1.83
1272	**Groom. 4163.**	7–6	49 14.9	2.861	+ 73 46 13	20.02	3.58
1273	*B. A. C.* 8322 .	6	51 20.9	2.998	+ 55 03 57	20.01	1.75
1274	ω Piscium . . .	4	53 24.4	3.078	+ 6 13 36	19.93	1.01
1275	**309 Cephei** . .	6–7	54 06.7	2.614	+ 86 03 58	20.03	14.58
1276	30 *Piscium* . .	5–4	23 56 03.7	+3.077	— 6 39 12	+20.01	1.01
1277	2 Ceti	4–5	23 57 50.8	3.076	— 17 58 34	20.05	1.05
630	**B A.C.**4070, S P.	6–7	11 58 56.8	3.081	+ 93 46 33	20.06	15.19
632	**Gr. 1852**, S. P.	6	11 59 23.5	3.136	+102 27 04	20.17	4.64
1278	33 Piscium. . .	5	23 59 26.9	3.071	— 6 21 03	20.15	1.01

FIELD CATALOGUE OF 1278 TIME AND CIRCUMPOLAR STARS.

Authorities.	No.	Notes.	
$H^{3.2}$ G^{5} Rd. R. $S^{2.1}$.	1253		
N. $G^{4.1}$ W. R. . . .	1254		
A. B. H^{2} $G^{3.1}$ Rd. R. S^{2}	1255		
C. B. $G^{5.4.3.2}$ W. Rd. R.	1256		
A.E.C.B.N.$H^{4.3.2.1}$$G^{5-1}$	1257	$H^{2} = i$.	
A.E.C.B. N. $H^{4.3.2}$ G^{5-1}	1258		
B. G^{3} Rd. R. . . .	1259		
B. H^{4} $G^{5.4.3}$ W. Rd. .	615		
N. H^{2} $G^{5.4.3.2.1}$ W. O. R.	1260		
B. G^{4} W. R. . . .	1261		
$G^{5.3}$ R. S^{2}	1262		
A. $H^{4.2}$ G^{3} R. . . .	1263		
$H^{4.2}$ $G^{3.1}$ Rd. R. $S^{2.1}$.	1264		
N.$G^{5.4.3.2.1}$ W. O^{1} Rd.R.	1265		
B. H^{4} $G^{5.4.3}$ W. Rd. .	1266	G^{5} = Brad. 3166.	
A.E.C.B.$H^{4.3.2}$ G^{5-1} W.	1267		
$H^{4.3}$ Rd. $S^{2.1}$ . . .	1268		
Rd.	622		
A. O^{1} M.	1269		
B. $H^{4.3.2}$ $G^{5.4}$ R. S^{3} .	1270		
B. $H^{4.2}$ $G^{4.1}$ W. Rd. R.	1271		
A.$H^{4.3.2}$ $G^{5.4.3}$ N.Rd.R.	1272	[7–6 mag.—$12^{s}.8 + 8' 02''$.	
$H^{4.2}$ G^{1} Bk. Rd. R. .	1273	Brad. 3185 : Rd = 6225.	
A. E. C. B. N. H^{4-1} G^{5-1}	1274		
H^{1} $G^{3.2}$ Rd. R. . .	1275	Brad. 3194.	
$H^{4.2}$ $G^{5.3.2.1}$ N. W. O^{1} .	1276		
C. $H^{4.2}$ $G^{5.4.3.2.1}$ W. R.	1277		
H^{3} $G^{5.4.3.2}$ W. Rd. R. .	630		
B. H^{4} Rd.	632		
A. N. $H^{4.2}$ $G^{5.4.3.2.1}$ W.	1278		

APPENDIX No. 19.

DETERMINATIONS OF GRAVITY AT ALLEGHENY, EBENSBURGH, AND YORK, PA., IN 1879 AND 1880.

By CHARLES S. PEIRCE, Assistant.

I.—GRAVITY AT THE ALLEGHENY OBSERVATORY.

The Allegheny Observatory is situated in—

Latitude 40° 27′ 41″.6 north,

Longitude 5^h 20^m 2^s.93 west of Greenwich.

It stands 1,140 feet (=348 meters) above the mean sea-level.* From a few yards in front of the observatory the descent is very sharp into the valley of the Ohio, and as this has been formed by erosion, it must be supposed to diminish the acceleration of gravity, perhaps by the one hundred thousandth part. Unfortunately the necessary calculation, which a topographical sketch would enable us to perform at once, remains impossible for the present.

The operations were conducted nearly as described in my "Measurements of Gravity at Initial Stations." The Repsold reversible pendulum was oscillated in vacuo on the Geneva support, in the cellar of the observatory, the feet of the support resting on iron bars laid upon other bars let into the great pier of the equatorial at one end and into a stone wall at the other.

Measures of the length of the pendulum were commenced 1879, January 2; but owing to the difficulty of maintaining a tolerably constant temperature in any part of the observatory that was otherwise suited for a comparing-room, no valuable results were obtained before January 18; and even after that date, it was found necessary to reject the work of several days, owing to bad conditions. The first series of measures of length was completed February 1. Four swingings of the pendulum were made on February 6 and 7 with heavy end up, and two swingings on February 8and 9 with heavy end down. On February 10, the position of the center of mass was determined and the knives were interchanged. Two days were then lost in trying to make the vacuum chamber stanch; after which two swingings were made with heavy end down, February 13 and 14, and four with heavy end up February 15, 16, and 17. On February 18 and 20, the flexure of the apparatus was measured, and these measures were supplemented by others on March 4. From February 22 to March 2, the pendulum was measured. The thermometers were compared from 1878, December 19 to 31, and again 1879, March 3.

The following table gives a synopsis of the results of the swingings, the period being corrected for the rate of the clock and for arc of oscillation, and being reduced to 15° C. and to a pressure of one million absolute C. G. S. units. The approximate pressure in millimeters of mercury and the approximate temperature centigrade are also shown. It is unnecessary to say that the air-pump was never brought into action during any swinging.

The agreement of the resulting periods is, as far as it goes, favorable to the plan of swinging *in vacuo*. It will be noticed that the oscillations were continued down to a small amplitude, but there seems to have been no increased error upon this account. Following the synopsis will be found a table of the errors of the partial swingings formed by intermediate transits, as shown on pages 502–503. The errors given are differences from the following periods, deduced from the final results:

T_d (knife 1)=1^s.0064527 T_u (knife 2)=1^s.0066434

T_d (knife 2)=1 .0064463 T_u (knife 1)=1 .0066370

* The latitude and longitude here given have been extracted from the American Ephemeris. The elevation is from data furnished to Professor Langley by the Allegheny City surveyor and by the engineer of the Pennsylvania Railway.

The errors are multiplied by the square roots of the number of oscillations, and the products are shown to be constant in the mean. It is also noticeable that this constant has the same value whichever end is up. Several obvious inferences might be made. In particular, it will be seen that the error of the result depends only on the total number of oscillations, no matter how they may be separated by intervals of rest.

HEAVY END UP. KNIFE No. 2.

Date.	Temperature.		Pressure.		Half arc in terms of radius.		Number of oscillations.	Corrected period.
	Maximum.	Minimum.	Beginning.	End.	Beginning.	End.		
1879.	°	°	*mm.*	*mm.*				*s.*
February 6.....	0.3	0.3	23	25	.023	.003	20,891	1.0066466
6.....	0.8	0.4	29	36	.030	.003	21,406	1.0066428
7.....	0.5	0.3	43	46	.030	.002	21,420	1.0066399
7.....	0.7	0.4	20	20	.034	.005	19,742	1.0066430
							83,459	1.0066431

HEAVY END DOWN. KNIFE No. 1.

February 8.....	0.7	0.1	13	14	.033	.002	74,805	1.0064533
9.....	0.3	—0.1	14	15	.035	.002	75,680	1.0064515
							150,485	1.0064524

HEAVY END DOWN. KNIFE No. 2.

February 13....	1.5	—0.5	17	40	.033	.002	61,844	1.0064471
14....	—0.3	—1.3	18	40	.035	.002	67,626	1.0064470
							129,470	1.0064470

HEAVY END UP. KNIFE No. 1.

February 15....	—0.6	—1.1	17	29	.034	.004	19,822	1.0066370
16....	—1.0	—1.2	17	35	.034	.004	20,766	1.0066337
16....	—0.9	—1.1	15	35	.034	.003	22,588	1.0066380
17....	—0.7	—0.9	21	37	.036	.003	20,848	1.0066411
							84,024	1.0066375

Errors of partial and total swingings.

Heavy end up.						Heavy end down.					
Knife No. 2.			Knife No. 1.			Knife No. 2.			Knife No. 1.		
Partial swingings.			Partial swingings.			Partial swingings.			Partial swingings.		
Error in 7th place.	Sq. root. No. oscill.	Product in 5th place.	Error in 7th place.	Sq. root. No. oscill.	Product in 5th place.	Error in 7th place.	Sq. root. No. oscill.	Product in 5th place.	Error in 7th place.	Sq. root. No. oscill.	Product in 5th place.
+43	57	25	+ 6	70	4	− 4	77	3	+80	78	63
+ 2	77	2	− 1	87	1	+ 48	83	40	+19	178	34
+24	83	20	− 3	86	3	+ 29	87	25	−27	94	25
+74	69	51				−180	31	56	− 9	88	8
			−66	85	56	+ 43	73	31	−35	87	30
+ 3	94	3	−13	79	10	+ 10	198	20			
−22	79	17	−18	85	15	− 61	93	57	−39	82	32
− 3	80	2							+38	88	33
			−15	82	12	+ 1	78	1	+53	83	44
−66	63	42	+28	92	26	+ 35	84	29	− 6	192	11
+30	59	18	+13	83	11	− 12	88	11	−23	95	22
−76	82	62				− 9	81	7	Mean of products.		29
−16	85	15	−28	81	23	− 11	178	20			
			+49	85	41	− 43	99	43			
+36	87	31	+99	83	82	− 19	82	16			
− 7	87	6	Mean of products		26	Mean of products.		26			
−58	73	42									
Mean of products.		24									
Whole swingings.			Whole swingings.			Whole swingings.			Whole swingings.		
+32	145	46	00	141	00	+ 6	273	16	+ 8	249	20
− 6	146	8	−33	144	48	− 12	275	33	+ 7	260	18
−35	146	51	+10	150	15	Mean of products.		24	Mean of products.		19
− 4	140	6	+41	144	59						
Mean of products.		28	Mean of products.		30						

Time was observed by Mr. F. W. Very, Professor Langley's assistant, with the instruments of the observatory, a fine 8-inch transit and the sidereal clock (Frodsham 1358). The chronometer, Negus 1589, was used for the pendulum observations; and this chronometer as well as two others (Hutton 202 and Bond 380) were compared upon the chronograph with the clock three times a day, between 3 and 4 o'clock in the afternoon and between 9 and 10 morning and evening.

The corrections to the chronometer used were obtained by assuming that between certain dates certain time-pieces moved with absolute uniformity, the changes of rate being supposed to be sudden. This is the same method of reduction used in my previous work, and appears to me most consonant with observed facts in regard to the running of timepieces. The standards used were as follows:

Date.	Sidereal time.	Timepiece assumed uniform from each time to next.
	h. m.	
February 4	6 18	Frodsham, 1358.
6	5 25	Do.
9	6 47	Do.
13	7 14	Hutton, 202.
15	8 02	Frodsham, 1358.
21	7 12	

The results of the comparisons of the length of the pendulum with the pendulum meter were as follows:

MEASURES OF LENGTH.

FIRST SERIES.

Date.	Pend. —standard.
1879.	μ
January 18	+26.1
January 21	+24.6
January 22	+26.4
January 23	+20.3
Mean	+24.3

SECOND SERIES.

	μ
January 25	+22.8
January 29	+25.5
January 31	+23.2
February 1	+18.6
Mean	+22.5

THIRD SERIES.

February 22	+11.3
February 23	+10.2
February 24	+ 9.9
February 25	+ 9.1
February 26	+12.1
March 1	+15.0
March 2	+11.6
Mean	+11.3

These results have to be diminished by $200^{\mu}.4$, because they are referred to the mean of the three lines $999^{mm}.7$, $999^{mm}.8$, $999^{mm}.9$ of the standard instead of to the meter. They have then to be increased by $261^{\mu}.1$ in order to be referred to the meter adopted in my "Measurements of Gravity at Initial Stations." It follows that the length of the pendulum in terms of the meter adopted in my previous work (which is now known to be erroneous, but which is for the present adhered to, in order to avoid confusion) was

	m.
Before the interchange of knives	1.0000853
After the interchange of knives	1.0000732

The difference of the distances of the center of mass from the two knife-edges was found to be $0^{m}.39303$, to which the correction, +.00014, has to be applied.*

The experiments to determine the flexure of the support have already been published in the Coast Survey Report for 1881, pp. 375–377. The mean of the measurements of two observers shows that the flexure at the middle of the knife-edge, under a horizontal force equal to the weight of the pendulum, was $38^{\mu}.8$.

We now proceed to calculate [T^2 Rev.] and [T^2 Inv.], as in the paper above referred to. Only, it is to be remarked that, in consequence of what is said on page 72 of that paper (page 271 of the Coast Survey Report for 1876), one-seventh of the viscosity effect has to be subtracted in order to eliminate the effect of the bells; that is to say, T_d has to be diminished by 66×10^{-7} and T_u by 151×10^{-7}. The values have to be separately calculated for the experiments made before and after the interchange of the knives.

Before the interchange of knives.

	s.		s.
T_d	1.0064524	T_u	1.0066431
Bells and cylinder	—145	Bells and cylinder	—321
	1.0064379		1.0066110
T_d^2	1.0129172	T_u^2	1.0132657
Flexure	—270	Flexure	—118
Stretching			+ 10
Corrected T_d^2	1.0128902	Corrected T_u^2	1.0132549

* See *Measurements at Initial Stations*, p. 114 (Coast Survey Report for 1876, p. 313), where the correction is, however, applied with the wrong sign.

After the interchange of knives.

T_d	$1^s.0064470$	T_u	1.0066375
Bells and cylinder	—145	Bells and cylinder	—321
	1.0064325		1.0066054
T_d^2	1.0129064	T_u^2	1.0032545
Flexure	—270	Flexure	—118
Stretching			+ 10
Corrected T_d^2	1.0128794	Corrected T_u^2	1.0132437

	Before interchange.	After interchange.
	s.	*s.*
Corrected T_d^2	1.0128902	1.0128794
Corrected T_u^2	1.0132549	1.0132437
$\frac{1}{2}(T_d^2+T_u^2)$	1.0130725	1.0130615
$\frac{1}{2}(T_d^2-T_u^2)$	—1824	—1822
$\frac{h_d-h_u}{h_d+h_u}\,\frac{1}{2}(T_d^2-T_u^2)$	— 717	— 716
$\frac{h_d+h_u}{h_d-h_u}\,\frac{1}{2}(T_d^2-T_u^2)$	—4638	—4633
[T^2 Inv.]	1.0130009	1.0129899
[T^2 Rev.]	1.0126087	1.0125982
[T^2 Inv.]—[T^2 Rev.]	3922	3917

The two values of [T^2 Rev.] combined with the two values of the length, give for the seconds' pendulum at Allegheny:

	m.
Before the interchange of knives	0.9930479
After the interchange of knives	0.9930461
Mean	0.9930470

This is the final result from this station alone. But the correction for the erroneous length of the meter, as provisionally stated in the Coast Survey Report for 1881, page 463, is -162×10^{-7}, giving

$$\overset{m.}{0.9930308};$$

and this may further be modified by the effect of measurements at other stations, and comparisons of [T^2 Inv.]. There is, however, reason to believe that such modification would be, in this case, insignificant.

Applying the correction for elevation, without continental attraction, diminished by one-tenth part, and the correction for latitude, as in my paper (C. S. Report, 1881, p. 445), we have

	m.
Seconds' pendulum at Allegheny	0.9930308
Elevation	+979
Latitude	—21903
Reduced to equator and sea-level	0.9909384

This would be increased if the effect of the valley were taken into account. A topographical sketch of this vicinity is the most pressing need of the work at this time.

The details of the work at the Allegheny Observatory are given in the tables appended to the edition of this Appendix, which has been published separately.

II.—DETERMINATION OF GRAVITY AT EBENSBURGH.

Ebensburgh is the chief (though not the principal) town of Cambria County, Pennsylvania, in the Allegheny Mountains. The observations were made in the house and grounds of Mrs. Frances S. McDonald, on Centre street. The place is shown on the county map by Beers (1867),

where the house has marked under it "J. M. McDonald." It is at the southeast corner of the street next south from Highland street. The transit pier is 23½ meters south of the northern boundary and 28½ meters east of the western boundary of the lot. The pendulum was observed in the cellar of the house.

The latitude of the station, +40° 27′, was determined by Mr. Marcus Baker by sextant observations upon the Sun, Jupiter, and Polaris. The longitude was determined by telegraphic exchanges with the Allegheny Observatory, the observers being Mr. F. W. Very and Mr. H. Farquhar with the result:

	h.	*m.*	*s.*
Ebensburgh east of Allegheny,	0	5	9.2
Ebensburgh west of Greenwich,	5	14	53.7

The elevation of the station has been ascertained from that of the railway at the station, as communicated by the engineer of the Pennsylvania Railway. The pendulum station was connected with the railway by a line of levels. The elevation so found is 2,137 feet (=651 meters).

It was intended to conduct the operations as at Allegheny; but various difficulties compelled me to support the pendulum on the Repsold tripod, as at my European stations. The brass foot-rests were placed directly upon the hard clay floor of the cellar. The old knives which had been used in Europe and in the stations at Hoboken and at Allegheny were replaced by new ones, made by Messrs. Darling, Brown, and Sharpe, of Providence. The amplitude of oscillation was measured on a fine arc by Messrs. Stackpole & Brothers, which is divided into thousandths of the radius. The arc and transits were observed with a reading telescope carrying an objective corrected for use at a short distance by Byrne, of New York. The same eye-piece was constantly used. The telescope was placed at a distance of two meters from the pendulum; and no screen was interposed between them.

The general order of the pendulum experiments was as follows:

1879.	
August 14–21.	—Measurements of length.
September 5.	—Swinging, heavy end down; knife, 3–4.
	Swinging, heavy end up; knife, 7–8.
September 6.	—Swinging, heavy end up; knife, 7–8.
	Swinging, heavy end down; knife, 3–4.
	Center of mass determined.
	Interchange of knives.
	Center of mass determined.
September 7.	—Swinging, heavy end down; knife, 7–8.
	Swinging, heavy end up; knife, 3–4.
September 8.	—Swinging, heavy end up; knife, 3–4.
	Swinging, heavy end down; knife, 7–8.
September 10–13.	—Measurements of length.
September 14.	—Swinging, heavy end down; knife, 7–8.
	Swinging, heavy end up; knife, 3–4.
September 15.	—Swinging, heavy end up; knife, 3–4.
	Swinging, heavy end down; knife, 7–8.
September 16.	—Determination of center of mass.
	Interchange of knives.
	Determination of center of mass.
	Swinging, heavy end down; knife, 3–7.
	Swinging, heavy end up; knife, 7–8.
September 17.	—Swinging, heavy end up; knife, 7–8.
	Swinging, heavy end down; knife, 3–4.
September 18–25.	—Measurements of length.

A synopsis of the periods of oscillation at Ebensburgh is given below. These periods have received not only the reductions for arc, rate, temperature, and pressure, but also peculiar *à priori*

corrections for flexure of the support, difference of knives, and injury to the pendulum. These I proceed to explain:

After half the swingings had been made, the pendulum was measured. In adjusting the microscopes a plumb-line was used; and to attach this it was necessary to remove the two forward nuts which bind the head of the support to the legs of the tripod. These were afterward replaced for the rest of the swingings, but instead of being tightened by a wrench they were only tightened by hand. This negligence was only discovered after all the swingings were completed, and it was then too late to repeat them. Elaborate experiments (see Coast Survey Report for 1881, Appendix 14) were accordingly instituted to determine the flexure of the support when the nuts in question were hand-tightened and when they were wrenched. The values given on page 388 of the Report have been used in the reductions, and the periods have accordingly received the following corrections:

	Heavy end down.	Heavy end up.
First four days	—.0000832	—.0000362
Last four days	—.0000895	—.0000390

The knives used at Ebensburgh and York, which are marked 3–4 and 7–8, have, at my request, been micrometrically examined by Assistant Edwin Smith, to determine the distance of the edges from the plane of the bearings. He obtained the following results:

Knife 3—4. At end marked 3, 122 . At end marked 4, 125$^{\mu}$.

Knife 7—8. At end marked 7, 168 . At end marked 8, 170 .

On September 11 the record notes that a small spring belonging to the attachment of the knife at the *light* end of the pendulum was found to be broken. In consequence of this the pendulum must have lost mass, and the center of mass should have been removed toward the heavy end. In examining the measures of the position of the center of mass, we find that at York, the station occupied after Ebensburgh, the center of mass was distant $0^m.30333$ from the knife-edge at the heavy end. In fact, using an empirical correction for the relative position of the knives, the individual results (16 in number) show a probable error of $\pm.000013$. At Ebensburgh, measures were made on September 6 and September 16. The four individual measures on September 16, with the correction for position of knives, give for h_u

m.
0.30330
0.30332
0.30330
0.30339

Rejecting the last observation, in which there seems to have been an erroneous reading, the others give $0^m.30331$, not differing sensibly from the value at York. The measures of the 6th give

m.
0.30324
0.30330
0.30327
0.30328

These show a value sensibly smaller than that of the 16th. The difference is such as would be produced by the loss of something less than a gramme at the *heavy* end. The distance between the knife-edges not having changed, no other changes can affect the result from the pendulum—considered as reversible—although the accident, whatever it was, must spoil the agreement of the different days. Although it does not affect the final result, I have, in the calculation, supposed that a gramme was lost at the *heavy* end, 2 centimeters beyond the knife-edge. The result of placing a small mass, m, on the pendulum at a distance of x meters and $l+x$ meters from the two knife-edges is easily found to be to increase the periods of oscillation by

$$\triangle T_d = T_d \frac{m}{M} \quad \frac{x(l+x)}{2h_d l}$$

$$\triangle T_u = T_u \frac{m}{M} \quad \frac{x(l+x)}{2h_u l}$$

Where M is the mass of the reversible pendulum, l the distance between the edges, h_d and h_u the distances of the center of mass from the two edges, and T_d and T_u the periods. In the present case we have $m=-1$, $M=6308$, $x=+.02$, $l=1$, $h_d=0.7$, $h_u=0.3$, $T_d=T_u=1$. We have, therefore,

$$\triangle T_d=-.0000023$$
$$\triangle T_u=-.0000054$$

and *these corrections have been applied to the first four days*, so as to reduce the pendulum to its state at the end of the work at this station.

Synopsis of periods of oscillation.

1879.	HEAVY END DOWN.	HEAVY END UP.
	Knife, 7–8.	Knife, 3–4.
	s.	s.
September 5	1.0064424	1.0065264
September 6	1.0064377	1.0065054
	Knife, 3–4.	Knife, 7–8.
September 7	1.0064482	1.0065122
September 8	1.0064400	1.0064296
September 14	1.0064377	1.0065024
September 15	1.0064389	1.0064789
	Knife, 7–8.	Knife, 3–4.
September 16	1.0064401	1.0065157
September 17	1.0064385	1.0064895

The period for September 8, with heavy end up, is obviously affected by an abnormal error. The Paris, Berlin, Kew, Hoboken observations show that the probable error of a period from a single swinging with heavy end up is $\pm 0^s.000006$. The period for September 8 differs from the mean of the others by $0^s.000077$, having thus an error about thirteen times the probable error, an event which would occur by chance only once in a million $\times$ million $\times$ million times. We may, therefore, safely say that on that day there was some extraordinary force tending to restore the pendulum to the vertical. The records of observations of arc show the following times of decrement on different days:

	From .0400 to .0180.	From .0180 to .0080.
	m.	m.
September 5	20.9	28.6
September 6	20.7	28.8
September 7	21.1	28.4
September 8	17.1	21.3
September 14	21.3	28.6
September 15	17.2	26.8
September 16	21.1	28.8
September 17	19.7	27.0
Mean 5, 6, 7, 14, 16	21.0	28.3

It thus appears that on the 8th there was some extraordinary force tending to bring the pendulum to rest. These facts suggest that a spider's line might on that day have connected the pendulum with the stand, and this supposition is somewhat strengthened by finding that on that day the operations commenced with oscillating the pendulum with heavy end up in the position in which it had been left the night before. On the 15th and 17th, also, the arc descended rapidly, the periods are very short, and the pendulum had been left over night with the heavy end up ready for the oscillations which were begun in this position in the morning. If there were spider lines on these mornings, we should expect the disturbing influence to decrease as the arc descended. Whether this is so in regard to the effect on the decrement on the 8th it is difficult to say, but it certainly is so on the 15th and 17th. Transits were observed shortly after the arcs reached .0400,

.0180, and .0080, so that there are two intervals from which periods can be deduced. These periods, corrected as in the synopsis, are

	HEAVY END UP. First interval.	Second interval.
	s.	s.
September 8	1.0064130	1.0064385
September 15	1.0064423	1.0064931
September 17	1.0064683	1.0065020

These numbers certainly confirm the hypothesis of spider-lines; and I shall consequently entirely reject the work with heavy end up on September 8 and the first intervals on September 15 and 17. With these rejections the mean periods for pairs of days in which the circumstances were the same, except the time of beginning (for on alternate days the position of the pendulum at the first swinging alternated), are as follows:

	Heavy end down.	Heavy end up.
	s.	s.
	1. 0064400	1. 0065159
	1. 0064441	1. 0065122
	1. 0064383	1. 0064978
	1. 0064393	1. 0065088
Means,	1. 0064404	1. 0065087

The time observations at Ebensburg were made with transit No. 5 carrying a reticule divided on glass by Prof. W. A. Rogers. The equatorial intervals of the five middle wires are sensibly equal to $2^s.583$. The pivot inequality was determined by Mr. Marcus Baker to be $+0^s.030$ with illumination west. Both lamps were in place during the whole of the observations, which were made by Mr. Henry Farquhar. The reductions were made by least squares, using Mr. Schott's weights of 1872. Separate azimuths were assumed for the two positions. The chronograph was a fillet-reed instrument, by Breguet. The battery consisted of two sulphate of copper gravity cells.

Chronometer Negus 1589 was always used for the star and pendulum observations, as this was undoubtedly our best chronometer. Chronometers Frodsham 2490, Hutton 202, and Bond 380, were compared with Negus twice daily. The two former break every second omitting the 0; the two latter break every even second, and also at 59^s. Frodsham and Bond were wound at 8.30 a. m.; Negus and Hutton at 8.30 p. m. at first, afterward at 9 p. m. until September 23, and after that at 6 p. m. Chronometers Negus, Frodsham, and Bond were in their external cases. All four rested firmly on sand heaped on the cellar floor about 15 cm. from an inner foundation wall and 30 cm. from one another. They were placed in this order: Negus, Hutton, Frodsham, Bond. The boxes of Hutton, Frodsham, and Bond were never opened except to wind them. The daily range of temperature in the cellar averaged less than 5 °C. The chronometers were compared with the clock of the Allegheny Observatory twice daily.

The measurements of length before the first interchange of knives were as follows:

	Pend.—standard.
	μ.
August 18	+16.4
19	+16.3
19	+16.9
20	+16.9
20	+21.5
21	+17.5
Mean	+17.6

But these measures are uncorrected for the difference of temperature between the pendulum and the standard; and in point of fact the former carried no thermometer. We may assume that the result should have a correction of $+2^\mu.4$ on this account, because this is the mean value of the correction in the following series. With this correction the mean result is that the pendulum was longer than the standard by $20^\mu.0$.

After the first interchange the results were these:

	Pend.—standard.
September 10	+19. 4
11	+18. 6
12	+18. 4
13	+19. 5
Mean	+19. 0

After the second interchange the results were as follows:

	Pend. standard.
	μ
September 23	+19.5
23	+20.3
24	+21.5
24	+21.3
25	+17.0
25	+17.7
Mean	+19.5

We conclude that the pendulum preserved the same length at all times, and was $19^{\mu}.5$ longer than the standard. The latter at 15° C. is $261^{\mu}.1$ longer than the meter assumed in the "Measurements of Gravity at Initial Stations"; so that in terms of that meter the length of the pendulum at 15° C. was

$$1^{m}.0002806.$$

The difference in the distances of the center of mass from the two knife-edges was found to be in one position

$$0^{m}.39351$$

and in the other

$$0^{m}.39352.$$

To these values must be applied a small correction, $+.14^{mm}$, which in the "Measurements of Gravity at Initial Stations" is correctly given, but is applied with the wrong sign.

The following is the calculation of the length of the seconds pendulum from the first four and last four days' oscillations at Ebensburgh:

	First days.	Last days.
	s	s
T_d	1.0064420	1.0064388
T_u	1.0065140	1.0065033
T_d^2	1.0129255	1.0129191
T_u^2	1.0130704	1.0130489
Corr. stretching	1.0130714	1.0130499
$\frac{1}{2}(T_d^2+T_u^2)$	1.0129985	1.0129845
$\frac{1}{2}(T_d^2-T_u^2)$	—730	—654
$(h_d+h_u):(h_d-h_u)$	2.54045	2.54097
[T^2 Rev.]	1.0128131	1.0128187
Same in mean time	1.0072880	1.0072936
Length pend	1.0002806	1.0002806
Sec. pend	0.9930432	0.9930379

Seconds pendulum at Ebensburgh = $0^{m}.9930406$.

This is expressed in terms of the erroneous meter having the provisional correction -162×10^{-7}. Applying as for Allegheny the corrections for elevation and latitude, we have

Seconds pendulum at Ebensburgh....	0.9930244
Elevation	+1827
Latitude	−21399
Corrected to equator and sea-level....	0.9910672

In the tables appended to the edition of this Appendix which has been published separately are given the details of the work at Ebensburgh.

III.—DETERMINATION OF GRAVITY AT YORK.

York, Pa., is situated east of the Alleghanies in a comparatively plain country. The pendulum was oscillated in the cellar of the factory of Mr. A. B. Farquhar, near the railway station, on Duke street. The transit was about a hundred yards to the east of the factory, on land belonging to Messrs. Billmeyer and Small, in Gay alley. The co-ordinates of the station are:

Latitude, 39° 58′ north.
Longitude, 5^h 05^m 54^s west of Greenwich.
Elevation, 122 meters (373 feet).

The work at this station was conducted by Mr. Henry Farquhar, under my supervision. The pendulum observations were partly made according to a method of eye-and-ear coincidences invented by Mr. Farquhar. For the purpose of studying the effects of flexure, the Repsold reversible pendulum was oscillated on various supports, viz: 1st, on the Repsold tripod; 2d, on a solid support formed by bolting the head of the Repsold tripod to an oaken plank 2 inches thick; 3d, on the Geneva support and tripod, with the bells off and with the bells on (this to ascertain the effect of the bells); 4th, on the Repsold tripod mounted on a wooden support; 5th, on the Repsold tripod resting on pieces of India rubber.

Experiments were also made at this station upon the effect of substituting rollers for the knives as the bearings of the pendulum. The rollers were steel cylinders of 5^{mm} diameter, backed by steel planes. They were well constructed by Messrs. Darling, Brown, and Sharpe. The utmost pains were taken (here as well as in later experiments in Baltimore) to avoid the inclusion of dust between the roller and its support. Nevertheless the decrement of the amplitude was very rapid for arcs above .035 of the radius on each side of the vertical; and the periods show enormous variations.

The experiments on the effect of the bells of the Geneva support are also of interest, though they fail to give a very accurate evaluation of this constant.

The summary of the periods of oscillation at this station (except upon the Geneva support) has already been published in the *Coast Survey Report* for 1881, pages 423–424. This summary is here repeated, with the difference that the flexure corrections are now applied, that some errors of computation are corrected,* and that the experiments relating to the effect of the bells are added.

* The following table shows these corrections:

Support.	Method of observation.	Position heavy end.	Date.	Correction to last figure.	Cause of former error.
Repsold ..	Transits ...	Up	May 2.	−9	Error in subtraction had occasioned rejection of a transit.
Do.....	Coincidence.	Down.......	Mar. 19.	−9	Error of computation.
Do.....	....do	....do	Mar. 21.	−1	Do.
Stiffest ...	Transits....	....do	Apr. 4, *bis*.	−3	Mr. Farquhar thinks he recorded the wrong minute, a fault to which he was liable. Changing the minute a rejected transit is brought into concordance with the others.

In drawing up the summary, besides the corrections for arc, pressure, temperature, and rate, the following have been applied:

Cause.	Authority for amount.	Amount.	
		Heavy end down.	Heavy end up.
Knife, 7–8 (for 3–4, with reversed sign)	See Ebensburgh report*	—.000006	+.000015
Flexure Repsold support	C. S. R., 1881, p. 424	—.000084	—.000036
Flexure stiffest support	C. S. R., 1881, p. 423	—.000022	—.000009
Flexure Geneva support	C. S. R., 1881, p. 399	—.000020	—.000009
Flexure wooden support	C. S. R., 1881, p. 423	—.000123	—.000054
Flexure rubber support	do	—.000300	—.000131
Geneva cylinder	C. S. R., 1876, p. 270	—.000004	—.000008
Geneva bells	C. S. R., 1876, pp. 270, 271	—.000019	—.000028

* At the time the paper on the flexure of pendulum supports was drawn up Mr. Smith had not measured the knives. It was consequently necessary to determine this correction *a posteriori* and slightly different corrections were thus used in the synopsis given in that report, viz, —.000004 and +.000012.

PERIODS OF OSCILLATION AT YORK.

REPSOLD SUPPORT.

Method of transits.

HEAVY END DOWN.		HEAVY END UP.	
1880.	Knife 7–8. s.	1880.	Knife 3–4. s.
April 7	1.006413	April 7	1.006467
April 30	1.006405	April 30	1.006446
	Knife 3–4.		Knife 7–8.
May 2	1.006418	May 2	1.006486
May 3	1.006418	May 3	1.006483

Method of coincidences.

	Knife 3–4.		Knife 7–8
March 19	1.006432	March 19	1.006490
March 21	1.006407	March 21	1.006440
June 4	1.006413	June 4	1.006472
June 5	1.006407	June 4	1.006450
	Knife 7–8.		Knife 3–4.
March 22	1.006422	March 22	1.006488
March 23	1.006406	March 23	1.006494
June 6	1.006421	June 6	1.006472
June 6	1.006429	June 6	1.006466

STIFFEST SUPPORT.

Method of transits.

HEAVY END DOWN.		HEAVY END UP.	
	Knife 3–4. s.		Knife 7–8. s.
March 31	1.006415	March 31	1.006467
April 2	1.006419	April 2	1.006472
	Knife 7–8.		Knife 3–4.
April 4	1.006410	April 4	1.006471
April 4	1.006417	April 4	1.006463

Method of coincidences.

	Knife 7–8.		Knife 3–4.
March 26	1.006419	March 26	1.006456
March 27	1.006423	March 27	1.006463
	Knife 3–4.		Knife 7–8.
March 28	1.006417	March 28	1.006461
March 29	1.006415	March 29	1.006463

WOODEN SUPPORT.

Method of coincidences.

	Knife 7–8.		Knife 3–4.
April 24	1.006420	April 24	1.006473
April 25	1.006417	April 25	1.006469
	Knife 3–4.		Knife 7–8.
April 27	1.006415	April 27	1.006470
April 28	1.006417	April 28	1.006488

RUBBER SUPPORT.

Method of coincidences.

	Knife 7–8.		Knife 3–4.
	s.		s.
April 18	1.006404	April 18	1.006484
April 20	1.006401	April 20	1.006482

GENEVA SUPPORT; BELLS OFF.

Method of transits.

	Knife 3–4.		Knife 7–8.
May 19	1.006425	May 19	1.006499
	Knife 7–8.		Knife 3–4.
May 22	1.006420	May 22	1.006488

Method of coincidences.

	Knife 3–4.		Knife 7–8.
May 18	1.006433	May 18	1.006509
	Knife 7–8.		Knife 3–4.
May 23	1.006431	May 23	1.006463

GENEVA SUPPORT; BELLS ON.

Method of coincidences.

	Knife 7–8.		Knife 3–4.
May 26	1.006432	May 26	Rejected.
May 27	1.006439	May 27	1.006485
May 29	1.006430	May 29	1.006459
	Knife 3–4.		Knife 7–8.
May 30	1.006432	May 30	1.006507
May 31	1.006437	May 31	1.006488

The means of the observed periods for the Repsold and stiffest supports are—

Method of transits.

	Heavy end down.	Heavy end up.
	s.	s.
Repsold support	1.006413 ± 1	1.006470 ± 5
Stiffest support	1.006415 ± 1	1.006468 ± 1
Weighted mean	1.006414 ± 1	1.006468 ± 1

Method of coincidences.

	Heavy end down.	Heavy end up.
Repsold support	1.006417 ± 3	1.006471 ± 5
Stiffest support	1.006419 ± 2	1.006461 ± 1
Weighted mean	1.006418 ± 2	1.006462 ± 1
General mean	1.006416 ± 1	1.006465 ± 1

It will be seen that the method of eye and ear coincidences is greatly inferior in accuracy, the eight observations taken in this way on the Repsold support being less valuable than the four by transits; and there can be little doubt that the means would be brought nearer to the truth by rejecting all the observations by these coincidences. We shall accordingly allow observations with this method only one-fourth weight. With these weights, the above periods become—

Corrected periods 1.006415 1.006468

The observations on the Geneva support, with the bells off, give

Heavy end down.	Heavy end up.
s.	s.
1.006424	1.006492

The differences from the corrected periods just ascertained are—

+.000009 +.000024

These numbers are in such a proportion as to indicate some force acting equally on the pendulum in its two positions. Experiments subsequently made in Baltimore, to be described in another memoir, leave no doubt that the effect is connected with the supporting planes of the Geneva receiver.

The observations with the bells on, all made by the method of coincidences, give—

Heavy end down.	Heavy end up.
s.	s.
1.006435	1.006485

From these numbers it would seem that the effect of the bells may be a little larger than was calculated; but the error, if any, can hardly be sensible when the receiver is pumped out.

The time observations were made with the same transit instrument used at Hoboken and at Ebensburgh. The eye-piece not being quite steady, the variations of collimation were considerable, and the instrument could not be kept free from dust. Time was kept by the four chronometers:

Negus 1589
Frodsham 2490
Hutton 202
Bond 380

They seem to have required cleaning, and show large diurnal variations. An attempt was made in the computations to take account of these, but not successfully.

The measurement of the pendulum on March 3 showed—

$$\text{Pendulum}-\text{standard}=+26.^{\mu}9$$

On May 7 and 8 three sets were taken with heavy end up, on which account 1. 0 has to be added to the results. (See "Measurements of Gravity at Initial Stations.") With this correction the results are as follows:

	μ.
Pendulum − standard =	+26.9
	+23.4
	+25.8
Mean	+25.3

On June 9, the knives having been interchanged, four sets gave

	μ.
Pendulum − standard =	+27.8
	+25.5
	+31.3
	+30.0
Mean	+28.6

These figures are uncorrected for the difference of thermometers on the pendulum and standard, because such correction would make the accordance of the measures much less good. We must assume the excess of length of the pendulum in the first position to have been $+26^{\mu}.1$, and for the mean of the two positions $+27^{\mu}.3$. Since the standard is $+261^{\mu}.1$ longer at 15° C. than the assumed meter, it follows that the length of the pendulum in terms of that meter (now known to be false) was

$$1^{m}.0002884$$

I prefer to retain the erroneous meter for the present, in order to avoid further confusion.

The difference of the distances of the center of mass from the two edges was found to be

Date.	Knife, 3-4 at heavy end.	Knife, 7-8 at heavy end.	First roller at heavy end.	Second roller at heavy end.
	m.	m.	m.	m.
March 22	0.39343	0.39353	....	....
March 28	0.39340	0.39349	....	....
April 26	0.39353	0.39351	....	....
May 10	....	....	0.39388	0.39387
May 30	0.39344	0.39353	....	....
Means	0.39345	0.39351	....	....

In the mean of the two positions of the knives we have 0.39348, to which .00014 has to be added on account of the error of the standard. (See "Measurements of Gravity at Initial Stations.")

The following is the calculation of the length of the seconds' pendulum at York:

$$T_d = 1.006415 \qquad T_u = 1.006468$$
$$T_d^2 \quad 1.012871 \qquad T_u^2 \quad 1.012978$$
$$\tfrac{1}{2}(T_d^2+T_u^2) \quad 1.012925 \qquad \text{Corr. stretching} \quad 1.012979$$
$$\tfrac{1}{2}(T_d^2-T_u^2) \quad -54$$
$$\frac{h_d+h_u}{h_d-h_u}\tfrac{1}{2}(T_d^2-T_u^2) \quad -137$$
$$[T^2 \text{ Rev.}] \quad 1.012788$$

Whence the length of the seconds' pendulum in York referred to the meter heretofore used is:

	$0^{m}.993073$
Provisional correction to meter	—16
Elevation	+104
Latitude	—2146
Reduced to sea-level and equator	0.991015

These reductions have been made, like those of Allegheny, in accordance with the principles of my memoir on the ellipticity of the earth (Coast Survey Report for 1881, Appendix No. 15).

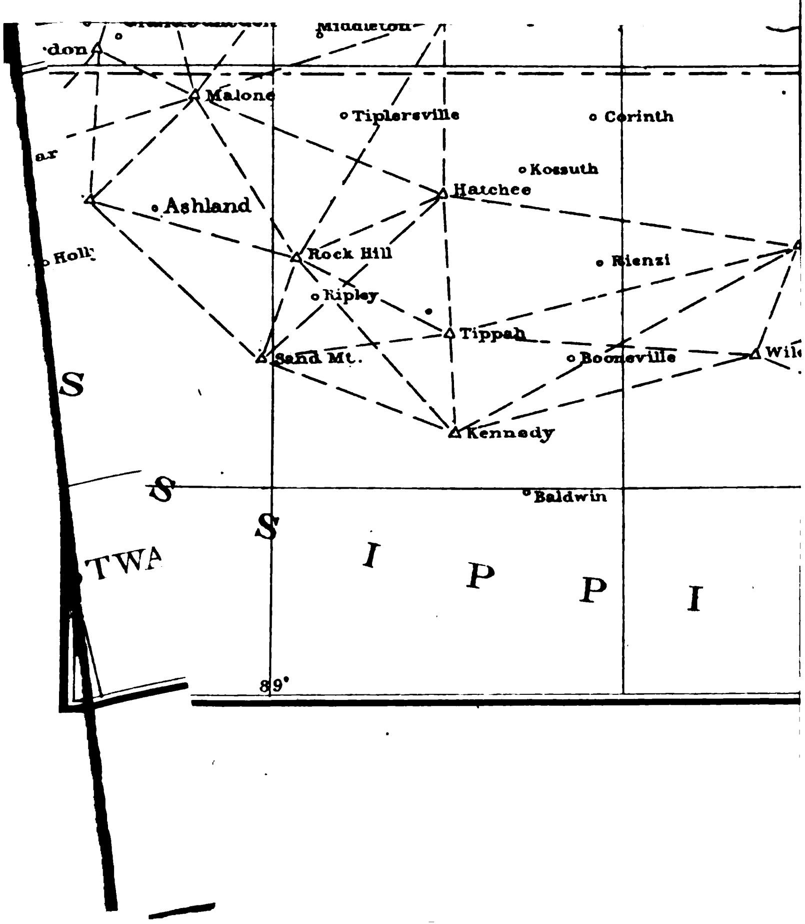
Details of the work at York are printed in tables appended to the edition of this Appendix which has been published separately.

LIST OF SKETCHES.

ILLUSTRATIONS.

4

3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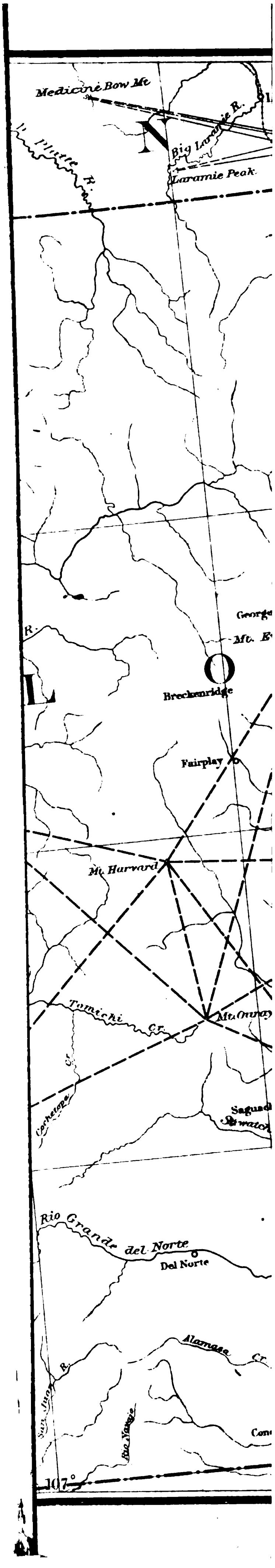
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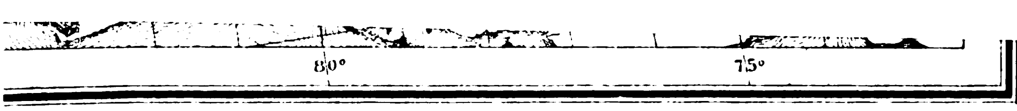
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